Effectiveness of an agricultural technology research and development project for increasing sustainability of cropping systems in upland areas of Yunnan Province, China

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Effectiveness of an agricultural technology research and development project for increasing sustainability of cropping systems in upland areas of Yunnan Province, China

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Abstract

Continued increase in population and escalating environmental degradation have changed the priorities of agricultural development projects in developing and emerging countries towards both increasing production or productivity and improving sustainability. The long-term success of these development projects, especially in terms of improving sustainability, depends on how widely those improved practices which are shown to be effective in achieving the technical objectives, are adopted/adapted by farmers in the targeted region. In these terms, many projects in recent years may be considered to be relatively unsuccessful.

This study aimed to investigate the factors contributing to the effectiveness of agricultural technology research and development projects in improving the sustainability of cropping systems in upland areas of China, together with the factors that might limit their effectiveness. This has involved both a review of recent projects carried out in the region and detailed monitoring and evaluation of one such project carried out in South West China – the SHASEA project.

The SHASEA Project was implemented in Wang Jia catchment in Yunnan Province using holistic and multi-disciplinary approaches to address the twin objectives of increasing productivity of maize, wheat and soybean in a more sustainable and environmentally-friendly way. It introduced into the catchment a range of novel or modified cropping practices, which had been evaluated in plot studies over the preceding six years, together with biological and engineering measures designed to stabilise large scale soil movements in lateral gullies and the main stream. The SHASEA Project was successful in achieving its short-term scientific and technical objectives, but was too short to determine the level of adoption by farmers in the locality.

The present study has used a range of approaches to evaluate the effectiveness of this Project, to monitor the biological, environmental and socio-economic impacts and investigate the perceptions of the farmers about the Project and the likelihood of their adoption of the recommended practices. Participatory approaches were used wherever possible, including detailed household surveys, PRA workshops and discussions with Key Informants. Field surveys and direct observations were also made, together with a limited economic analysis of the modified cropping practices introduced into the catchment.

It was found that the farmers had different perceptions about the range of practices introduced into the catchment. Some were clearly preferred, such as contour cultivation and were likely to be adopted, while others were seen as inappropriate, such as straw mulching and intercropping, and were unlikely to be adopted. The benefits of an innovative, integrated cropping system, INCOPLAST, were not fully appreciated by the farmers. Other practices would only be adopted if the financial returns were favourable, such as the use of polythene mulch. Longer-term measures, such as tree planting schemes, were regarded favourably, but adoption would still depend on economic returns and related issues such as land security. An irrigation scheme was suggested by the farmers, but after installation it was not used extensively for the staple crops in the catchment. It was found that farmers planned to use the irrigation for higher value crops such as tobacco, after the end of the Project.

It has been concluded that, despite the technical and scientific success of the Project, long-term adoption of many of the practices introduced into the catchment will be low, unless considerable incentives are used or much more effective dissemination techniques employed. It is considered that the outcomes would have improved considerably if participatory approaches had been used from the outset, to engage farmers more fully with the project, to ensure that the practices introduced were as appropriate as possible, to achieve greater ownership of the objectives and outcomes, leading to higher adoption rates. More emphasis should have been given to the dissemination of the outcomes at farmer level outside the catchment of study and there should have been more involvement with the regional policy makers and extension officials throughout the programme. Longer-term improvements in sustainability at the catchment level have not yet been demonstrated.

These outcomes are discussed within the context of other agricultural projects carried out in South East Asia and other developing regions.

Based on the outcomes and conclusions from this study, a series of recommendations are made which are presented as good practices for future agricultural development projects in South East Asia.

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Chapter 1. General introduction

Up to the 1960s, increasing demand for food was met in developing countries mainly by expanding the land area under cultivation, evident from the 40% rise in the total arable area in the world (from 1 billion hectares to 1.4 billion) between 1927 and 1960 (Evans, 1998). The World's population reached three billion by 1960 and the rate of population increase was highest (2.1% per year) between 1965 and 1975 (Evans, 1998). This created an even greater demand for increased food production, particularly in developing countries, with most of the easily available land already in cultivation. The increasing gap between the total population and total food production imposed further pressures for producing more food and fibre from approximately the same land area (Bridges and Oldeman, 2001). In pursuit of satisfying food demand, peoples' activities focussed on increasing production without due attention to the resultant effects (both short and long term) on natural resources. This is evident from the fact that humans today use ~12,000 times more energy, mainly in the form of fossil fuels, than they did 400 generations ago (Munasinghe and Shearer, 1995; Walmsley, 2002). As a result, per capita availability of usable resources has declined further, adversely affecting agricultural production (Pratap and Watson, 1994) and making the long-term viability of current agriculture systems doubtful (Rigby *et al.*, 2001). This situation is more apparent in poor and developing countries, which depend more on natural resources for their income. Environmental degradation and poverty generally go hand in hand, particularly in agricultural countries (Bie *et al.*, 1997).

After 1960, increasing emphasis was placed on crop intensification involving new cultivars and increased use of fossil fuel, fertilisers, chemicals and machinery. Scientists were able to modify the morphology and physiology of crop varieties, through plant breeding approaches, making them more responsive to high inputs. This led to a dramatic increase in the use of chemical inputs in agriculture. The combination of high yielding cultivars and high inputs formed the basis of the 'Green Revolution' (as described by the USAID Administrator, W. S. Gaud in 1968; Evans, 1998). However, high production goals were prioritised without appropriate consideration of the resultant effects of such production techniques. As a result, the production systems in different parts of the world witnessed various problems associated with land degradation, soil erosion, water pollution and resource depletion (Lal *et al.*, 1988; Pratap and Watson, 1994; Evans, 1998; Hurni, 2000; Röling, 2005).

As these problems were identified, there was increasing awareness of the need for more sustainable, environmentally friendly cropping practices (Agenda 21, 1992). Therefore, in the last 25 years, agricultural development projects in developing countries have focussed primarily on two key objectives. First, continuing the increases in production/ productivity of food crops to meet increasing demand for food; second, improving the sustainability of cropping systems, by reducing the adverse impact of intensification and conserving natural resources (Wills *et al.*, 1987; Gerpacio, 2001; ICRISAT, 2002; IRRI, 2003; CIMMYT, 2004).

Substantial resources have already been invested to generate technologies for more sustainable agricultural intensification in developing countries. For example, official international assistance for agricultural development alone was >9 billion $/year during the 1980s and 1990s, reaching as high as 13-14 billion $/year during 1982-86 (Trotter and Gordon, 2000). As a result, there were significant achievements in the improvement of agricultural technologies. In most cases, these new technologies were more effective in increasing production and productivity than existing technologies. However, many of these new technologies considered 'effective' have not been instrumental or successful in alleviating the associated sustainability problems, due to poor dissemination and/or adoption of the technologies by the targeted users (Tang Ya, 1999; Neupane *et al.*, 2002; McKemey *et al.*, 2003). In this context, success of any novel technical intervention should be judged on the basis of widespread adoption in the target area by the targeted users (Garforth and Usher, 1997; Garforth, 1998). So, it is timely to find appropriate answers to the question: 'Why is a technology, considered 'effective' on the basis of scientific evaluation, not adopted by the targeted user, for whom it was developed?'

- Are the technologies inappropriate for the target area for other reasons?
- Are the farmers unaware of, or not engaged, with project outcomes? Was the participation of the farmers consolidated in the technology generation and dissemination processes?
- Are the technologies too labour-intensive (not economically feasible)? Will farmers only implement technologies that give a substantial economic return without large increase in effort, for example, use of improved varieties or pesticides?
- Are farmers more interested in investing their labour in more lucrative off-farm activities?

A better understanding of the reasons for poor adaptation and adoption of agricultural technologies, from a consideration of projects designed to implement technologies for improving sustainability, should lead to enhancement of future agricultural development interventions. This is necessary not only to improve the effectiveness of such projects but also to save resources, both human and financial, from being wasted in developing technologies that are not used.

The aim of this study is, therefore, to determine factors contributing to the effectiveness of agricultural technology research and development projects in improving the sustainability of cropping systems in upland areas of China. This will be attempted through three approaches:

a. By a review of the relevant literature relating to agricultural sustainability and agricultural technology projects developed to improve sustainability in South East Asia.
b. By a review of the background and outcomes from one such project recently completed in the region.
c. By further evaluation and monitoring of this project using a number of different methodologies.

The objectives for the first part of the study are:

1. To identify current themes and practices relating to agricultural sustainability, with particular reference to the development and implementation of cropping technologies designed to improve sustainability, by a review of the relevant literature.
2. To identify factors that may have contributed to the effectiveness and degrees of success/failure by reviewing specific projects and programmes implemented in South East Asia, which include a component of research and development on cropping technologies.

The second and third approaches have been carried out through independent study of the 'Sustainable Highland Agriculture in South East Asia' (SHASEA) Project. This was located in a catchment adjacent to Kelang Village, north east of Kunming City, capital of Yunnan Province, South West China. The objectives for the second approach are:

3. To give a description of the socio-economic background of Kelang Village, to establish in part the context for the present study, including an assessment of its suitability as the location for the experimental site.
4. To produce a description of the rationale, methodologies and outcomes of the SHASEA Project, summarising the conclusions drawn and attempting an evaluation of the short-term results of the project; this will also provide further contextualisation for the present study.

The objectives of the third approach, which constitutes the main component of the present study, are:

5. To determine the perceptions of local farmers (family households) on the effectiveness of the technologies introduced by the Project and the likelihood of their future adaptation and adoption, using both household surveys and participatory rural appraisal.
6. To determine the views of available local stakeholders on the technologies introduced by the Project, their initial impact, dissemination, possible extension, adaptation and adoption.
7. To complete an additional analysis of the biological, environmental and economic impacts of the Project technologies, through further monitoring by field survey, direct observation and economic analysis.
8. To achieve a synthesis of the outcomes from the approaches identified above to obtain a more holistic view of the impact of the Project, its short-term outcomes and potential longer-term effectiveness in relation to future adaptation and adoption, leading to the final conclusions of the present study.
9. To identify good practices for the development, implementation and dissemination of similar projects in the future.
10. To identify the limitations of the present study and outline areas for future study.

In this context, SHASEA is a good example of a recent project that aimed to improve both the productivity of staple crops and also sustainability in terms of improved soil conservation, working with local farmers at a field scale. SHASEA is considered to be a very successful project in terms of achieving its scientific outcomes (SHASEA, 2003). This is also evident from the high appreciation from the European Union (funding organisation) for high quality outputs, mutual co-operation and holistic vision (Pottier, 2002, *pers. comm.*). However, despite generating effective technologies, it is important to consider if the Project has been successful in achieving wider adoption of these technologies.

This study is part of the longer term monitoring of post-Project impacts, with particular emphasis on evaluating farmers' perceptions of the Project and the perceptions of other local stakeholders. Extracting the views of these stakeholders, particularly farmers, is challenging in China, mainly due to difficulties in communication and the socio-political situation. To take account of these difficulties, a multi-approach participatory evaluation study was designed, involving different participatory tools/techniques, such as household interview, PRA group discussions, farmers' workshops, discussions with key informants and subject matter specialists and direct observations. This provided an opportunity to triangulate and verify the information collected from different sources.

Three visits to the Project site were made, one each during 2001, 2002 and 2003, to carry out the field study. The visit in 2001 involved a two week-long familiarisation visit to Wang Jia catchment and Kelang village where the Project activities were implemented. This provided an opportunity to obtain first hand information about Project activities and the Project site, which was very helpful in designing this study. The field visit during 2002 was primarily focussed on studying the farmers' awareness and perceptions of the Project technologies and development interventions. During 2003, the study focussed on the adoption of Project technologies by farmers and issues associated with the sustainability of the cropping practices introduced by the SHASEA Project.

The outcomes from this study have been organised into nine Chapters (Fig 1.1).

Findings of the literature review on issues surrounding agricultural sustainability are presented in Chapter 2. The information is presented under five sections, i.e. sustainability of agricultural systems, technologies for increasing the sustainability of cropping systems, sustainable agricultural projects in S. E. Asia, effectiveness of the projects implemented in S. E. Asia and some issues related to the success and failure of sustainable agricultural projects. This chapter also includes a section (section 2.3.1) on the theories underpinning development projects, their evolution and evaluation. From this consideration, the systems used by the SHASEA Project are categorised, but this theoretical approach is not developed further in this thesis.

In Chapter 3, an introduction to Wang Jia catchment and Kelang village is presented. Information about geographical and demographic features and major historical events are presented and governance, land use and economic activities in Wang Jia catchment and Kelang village are discussed.

Chapter 4 presents information about the SHASEA Project, reviewed from Project documents and researchers' theses. The Project is introduced, with a brief account of the historical background followed by a description of Project activities and outcomes.

Chapter 5 presents the results of the household survey of farmers' perceptions of the Project technologies and their willingness to adopt the technologies in future.

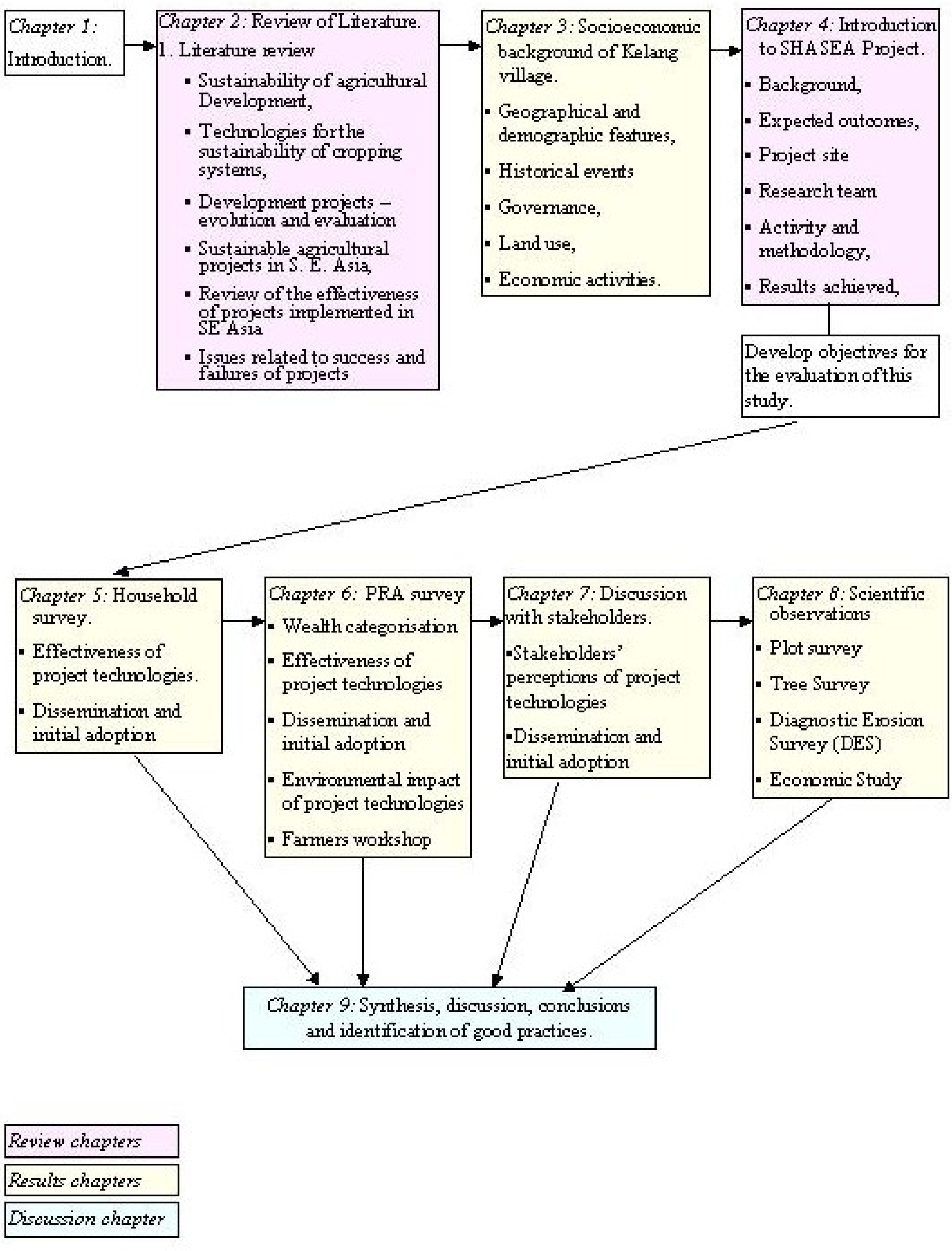

Figure 1.1 Map of the Thesis.

Chapter 6 presents the results from the Participatory Rural Appraisal (PRA - group discussions). As in Chapter 5, farmers' perceptions of the project technologies are presented and their willingness to adopt the technologies in future are discussed. However, the focus here is on studying the issues at a broader level (beyond the household level) in which the farmers in a group may have common opinions. Results from participatory group exercises for wealth categorisation and comparison of catchments for the evaluation of environmental conditions are also presented.

Chapter 7 presents results from discussions with local stakeholders (key informants, Project researchers, local political leaders, extension agents and local/regional policy makers). These were undertaken as part of a triangulation approach, providing further evidence in an attempt to verify the results from other sources.

Chapter 8 presents results of four separate direct observation and analytical studies, i.e. a plot survey, a tree survey, a diagnostic erosion survey and a limited economic analysis of some of the introduced practices, based on information obtained from agricultural extension advisors and farmers.

Chapter 9 attempts to synthesise the outcomes from the different approaches described in previous chapters, discuss the findings in a broader context and draw conclusions from the work.

Chapter 2. Review of literature and projects on sustainable agriculture

2.1 Literature Review

The review will focus on the sustainability of cropping systems, with particular reference to the impact and effectiveness of agricultural development projects in S.E. Asia, including S.W. China. Major aspects of sustainability studied in this section are: definitions of sustainability, factors affecting agricultural sustainability, indicators of sustainable agriculture, technologies for improving sustainability of cropping systems, sustainable agriculture projects in S.E. Asia, effectiveness of the projects implemented in S.E. Asia and identification of issues related to successes and failures of sustainable agriculture development projects.

2.1.1 Sustainability of agricultural development

As outlined in Chapter 1, the World's growing population is placing increasing pressure on global resources, particularly soil and water. The pressure on natural resources is more evident where there are higher rates of population increase or areas of marginal, fragile land, such as highland areas. In China, prior to imposition of effective birth control policies, rapid population growth and associated food shortage problems led to continuing intensification of agriculture (Wang ShuHui, 2003). Increasing pressure on flat land through industrialisation and urbanisation has placed even greater pressure on more marginal, sloping land. In these areas, earlier deforestation had already caused extensive land degradation leading to accelerated soil erosion. Consequently, the problems associated with intensification are more serious in China than most other countries in the World (Cai *et al.*, 2000) and present an enormous challenge for the future. In Yunnan Province, S. W. China, ~ 70% of its 4.63 million hectares of cultivated land is located on sloping areas (Yunnan Province Soil Survey Department, 1989; Huang BiZhi, 2001). Most of this land not only suffers from soil erosion *per se,* but also contributes to the sediment loading in the Yangtze River and hence downstream flooding. Similarly, crop yields on sloping land in South China have decreased by 30-60% because of soil erosion (Gao Zhu and Zhou Lie, 1988). It has been estimated that if current erosion rates continue, in 50-100 years most topsoil will have been removed (Shi Deming, 1987). More effective soil conservation, while maintaining or increasing productivity, is an essential goal if agriculture is to be sustained on sloping land in these highland areas.

2.1.1.1 What is sustainability in an agricultural context?

The definition of 'sustainable' is *'something that can be kept going or maintained'* (Oxford English Dictionary, 1995). In other words, if something can be continued over the longer period in its present state, it is sustainable. This is continuation without interruption in process and deterioration in quality.

Sustainable agriculture is centred on the same concept, but it can be discussed from different perspectives, with different terms being used, for example: ‘sustainability’ (Gorrie, 1999), ‘sustainable development’ and ‘environmental sustainability’ (CSD, 2001). Specific forms of sustainable agriculture include ‘ecological agriculture’ (Wu ShanMei *et al.*, 1989; Miao and Marrs, 2000), ‘agro-ecosystems’ (Kropff *et al.*, 2001). Different aspects relating to sustainability can be emphasised, for example: ‘soil and water conservation’ (Pretty and Shah, 1997; Fullen *et al.*, 2001), ‘watershed management’, ‘watershed sustainability’, ‘sustainable land management’ (Carter, 2002), ‘sloping land management’ (Maglinao *et al.*, 1995; Sajjapongse and Leslei, 1998), ‘biodiversity management’ (Lovejoy, 1994), ‘food security’, ‘rural development’ (Green, 1989) and ‘poverty alleviation’ (Nesbitt, 1997; AusAID, 1999a; Monschein, 1999; IDRC, 2003).

Different organisations and authors have produced different definitions of sustainable development and sustainable agriculture, including the following examples:

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development (WECD), 1987).

“The concept whereby improvements in quality of life through economic development is not gained at the expense of the environment or of future generations” (DfID, 1998).

“Improving the quality of human life while living within the carrying capacity of supporting ecosystems” (IUCN, 1991).

“Continued economic and social development without detriment to the environment and the natural resources on which human activity and future development depend” (Directorate General XI of the European Commission as cited by DfID, 1998).

“A sustainable agriculture is ecologically sound, economically viable, socially just and humane” (Alliance for Sustainability, 2000).

“A sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and

fibre needs; is economically viable; and enhances the quality of life for farmers and society as a whole" (American Society of Agronomy, 1989 as cited by Janke *et al.*, 1998).

"Sustainable agriculture is the management and utilisation of the agricultural ecosystem in a way that maintains its biological diversity, productivity, regeneration capacity, vitality and ability to function, so that it can fulfil – today and in future – significant ecological, economic and social functions at the local, national, and global levels, and that does not harm other ecosystems" (Eckert and Breitschuh, 1994 as translated and cited by Lewandowski *et al.*, 1999).

The definition of sustainable agriculture presented by the Food and Agriculture Organisation (FAO) of the United Nations is more relevant to this study, which cites the definition as *"Sustainable agriculture should involve the successful management of resources to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources"* (FAO, 1989). Subsequent discussion on sustainable agriculture in this thesis will be based on this definition.

Construction of a more precise definition of sustainable agriculture, applicable to such a wide variety of geophysical and socio-economic situations, is probably not feasible. Despite the variation in the wording, the central theme contained in most definitions is on improving or maintaining output while maintaining or enhancing the quality and regenerative potential of natural resources. There has to be a balance between the needs of current generations and those of future generations. So, contemporary generations may produce (and have) as much as they want, but without diminishing the present state of natural resources (Korthals, 2001). This stresses the provision of appropriate compensation penalties for the actions of the current generation, where these are likely to have negative repercussions on the well-being of future generations (Bie *et al.*, 1997). The Organisation for Economic Co-operation and Development (OECD) translated this principle into practice by adopting the 'Polluter Pays Principle' in the early 1970s (OECD, 1998). In this way, sustainable agriculture stresses maintaining the use value of available resources (Walmsley, 2002). Therefore, sustainable agriculture requires understanding of and working with the systems perspective, which involves a holistic approach, long term perspectives, multi-/inter-disciplinary efforts and effective stewardship of available natural resources. In recent years, there has been growing demand for more multidisciplinary and holistic approaches to agricultural research and development (Cai YunLong and Smit, 1994). Progress towards achieving sustainability can only be made through the joint efforts of all stakeholders. In this way, accomplishing (planning, implementation, evaluation and scaling up) sustainable agricultural activities requires participatory processes. However, principles of sustainable agriculture do not tender a defined set of practices for any particular condition, instead these force practitioners to think about the long-term effects of human activities on natural, economic and social systems.

Agricultural sustainability may be influenced by both the internal system (mainly biophysical) and external factors (mainly economic, social and policy related) (Cornforth, 1999). Thus, agriculture must be biophysically possible, socio-politically acceptable and technically and economically feasible in order to be sustainable (Cai YunLong and Smit, 1994).

2.1.1.2 Factors affecting agricultural sustainability

Great variation exists in geophysical situations, socio-political contexts and problems associated with agricultural systems between developed and developing countries. Owing to this variation, different factors play different roles in sustainability in different countries. In the industrialised agricultural systems of Europe, high inputs and variable costs are the main factors affecting sustainability. In the 'Green Revolution' areas, the challenge is to maintain current yields, while reducing environmental damage. In addition, in the diverse and complex situation of developing countries, low yields and environmental degradation are major factors responsible for challenging agricultural sustainability (Pretty, 1995). The major factors affecting agricultural sustainability have been grouped into categories described in the following sections.

2.1.1.2.1 Technical factors

Many different technologies have been described as 'sustainable agricultural technology'. Among them, maintenance of productivity plays a key role in agricultural sustainability (Lewandowski *et al.*, 1999). Sustainability of an agricultural system depends on the level of use of resource conserving technologies, for example integrated pest management, soil water conservation, nutrient recycling, multiple cropping, water harvesting and waste recycling (Pretty, 1995). Similarly, use of multi-functional technology (single technology that leads to favourable changes in several components of the farming system), for example rice-fish-azolla system, favours agricultural sustainability (Pretty, 1995).

The Swedish University of Agricultural Sciences (SUAS) reported that greater success of soil conservation interventions occurs on the more fertile terraces and irrigated land and with the use of inorganic fertilisers (SUAS, 1990). Consequently farmers in resource poor marginal areas have not been able to realise the benefit of sustainable development intervention to the same extent as farmers from resource rich areas. Recommendation of new technology must be accompanied by access to the required inputs. For example, the diffusion of *Rhizobium* inoculation technology in Shanxi Province, China, was impeded by the unavailability of bacteria (SUAS, 1990).

2.1.1.2.2 Environmental factors

The status of internal biological processes, for example stock of natural predators and wild host plants, soil nutrients levels and soil structure and abundance of vegetation and trees in the system, are major factors affecting agricultural sustainability (Pretty, 1995). Reductions in the initial stock of renewable resources lead to unsustainability (Pasqual and Souto, 2003). Environmental parameters, such as canopy cover, litter layer and wood debris, are important factors that determine soil erosion and hence sustainability of the systems (Hartanto *et al.*, 2003). Unequal distribution of natural resources and unequal population distribution increases social tension, adversely affecting long-term sustainability (D'haeze *et al.*, 2005).

2.1.1.2.3 Economic factors

Most of the novel sustainable agricultural technologies require change in various aspects of the existing system, for example, management skills, knowledge, time and amount of labour required. This exerts financial pressures on farmers while, conversely, farmers may not see the economic benefits in the short-term (Pretty, 1995). This situation impedes the adoption of such novel technologies by farmers, as direct cash income is one of the major factors driving the process (Tang Ya, 1999).

2.1.1.2.4 Working approach

Thompson and Pretty (1996) reported that the impacts of a soil conservation programme varied according to the quality of the interaction between extension staff and local people. The impacts were substantially greater when participation in planning and implementation was interactive and interdisciplinary, than when participation was simply consultative.

External supporting institutions are increasingly changing their roles to become facilitators, rather than directing the local implementing organisations, as the participatory approach has been found more effective in achieving programme objectives compared to the top-down technology transfer approach to information dissemination (Thompson and Pretty, 1996). This is a major shift in the existing paradigm of institutions working towards agricultural sustainability. Change in the policies of funding/supporting organisations is one of the reasons for this paradigm shift.

2.1.1.2.5 Farmer (grass root) factors

Local people, particularly farmers, are the primary users of natural resources. So the use of natural resources, leading to positive or negative impacts on system sustainability, is strongly influenced by their decision–making processes (Wattenbach and Friedrich, 1997). Farmers in developing countries are generally poor and deprived of even basic goods and services, so maintaining or improving livelihoods is their prime objective for any change in their farming system (Wattenbach and Friedrich, 1997). They analyse the possible effect of any advice or option on their livelihood strategy and give less preference to changes which do not have clear benefits to their standard of living. The changes that affect their condition are screened through their own decision-making processes, analysing the possible effects of the change involving pragmatic indicators. This ultimately decides the adoption of such interventions (Shaxson, 1997). The importance of farmer participation is reported in goal setting (Jain *et al.*, 1997; Subedi *et al.*, 2001), natural resources management (Bhatia and Karki, 1999; Ritsema *et al.*, 2001; Evans and Sophana, 2004; SFDP, 2004), technology transfer (Acton and Thai Phien, 2001), and enhancing farmers' adoption (Howeler, 1996).

In agricultural sustainability perspectives, islands of success by a few households rarely lead to any visible impact on the catchment scale. Sustainable agriculture involves judicious and rational use of input and natural resources as a common approach, for example in pest and predator management, utilisation and management of forest and water resources and soil-water conservation (Pretty, 1995). Programme sustainability depends to a large extent on group action and implementation by local people.

Various types of grass root initiatives can play important roles in the development of agricultural system sustainability, such as:

- Community based organisations (CBO) (Pretty, 1995; McKemey *et al.*, 2003).
- Natural resource management groups (Pretty, 1995).
- Producers' group (Neupane *et al.*, 2002), consumer groups (Pretty, 1995), forestry user groups (Garforth *et al.*, 1999; McKemey *et al.*, 2003).
- Credit management groups (Pretty, 1995).
- Farmers' research committees (Pretty, 1995; Subedi *et al.*, 2001).
- Farmer to farmer extension groups (Pretty, 1995; Neupane *et al.*, 2002).

The role of these groups is particularly important in providing common fora for making collective decisions and sharing knowledge and skills. Moreover, such groups play important roles in motivating less interested farmers. When an interactive participation of local people and a multidisciplinary team is achieved during the planning and implementation of a programme, the impacts are substantially greater than when participation is simply consultative (Thompson and Pretty, 1996). It makes sense to involve those who have the most information and long-term experience about the land and local ecosystems.

2.1.1.2.6 Social Factors

Poverty and disparity, particularly economic, are among the major social factors affecting sustainability. Increase in poverty leads to over-use of natural resources. Poverty is both a cause and an effect of environmental degradation (Raskin *et al.*, 1998). Similarly, disparity increases social tension and sustainability ceases to be the aspiration of a person or community in places where social tension exists.

2.1.1.2.7 Institutional Factors

The evaluation mission of the Chinese-Swedish Soil Conservation Cooperation (CSSCC) Project reported that the Project had shown an admirable capability to mount sound, technically reliable experiments. However, the research-extension linkage in the project was poorly developed; as a result, the mission found few cases where results from the Project had been disseminated through extension systems (SUAS, 1990). There was a lack of institutional capacity to undertake farming system research, so this was not planned in the original project design. As a result, there was insufficient understanding about the main farming problems and the appropriate method of information dissemination was not sufficiently developed. In the context of implementing a participatory soil conservation programme, Thompson and Pretty (1996), suggested that the external supporting agency must become more of an enabler and less of an implementer in order to make such programmes sustainable.

2.1.1.2.8 Scale and duration of operation

SUAS (1990) suggested that project duration of at least five years is required to produce any tangible output from agricultural interventions, which are typically long term in nature. A three-year project period was found to be insufficient to yield any visible output from activities like agro-forestry in relation to soil fertility. In a similar notion, Hudson (1991) suggested that a 10 year horizon should be the norm for producing any impact on sustainability.

2.1.1.2.9 Temporal dimension of the impact

Poor subsistence farmers are generally equipped with poor buffering capacity against any undesired and casual economic shock. The next meal is their immediate problem, which they try to manage by any means, i.e., sustainable or unsustainable. Under such circumstances, technology/policy interventions that provide short-term benefit are likely to be adopted more than those that provide benefit in the longer term. However, in response to this notion, some programmes/ projects have changed their original philosophy of developing eco-friendly sustainable development interventions by involving chemical means to achieve more tangible benefits in a short time frame. In the CSSCC Project, in contrast to the original philosophy to improve production through enhancement of soil organic matter levels, the shorter term expediency of applying chemical fertilisers came to dominate experiments (SUAS, 1990).

2.1.1.2.10 Political and policy-related factors

Government policies and the means through which they are implemented are major instruments to influence the behaviour of land users (McKemey *et al.*, 2003). Many countries recognise sustainable agriculture as a long term policy objective and developing sustainable agricultural strategies as part of broader national environmental and sustainable development objectives (OECD, 1998). Agricultural sector and agri-environment policies at the international level are being guided by many different factors, including:

- The process of globalisation and the commitment to agricultural policy reform and trade liberalisation within the context of the World Trade Organisation (WTO).
- The decisions of the Rio Summit in 1992 and the Rio+5 in 1997 for sustainable development.
- The commitment to reduce greenhouse gas emissions made under the Kyoto Protocol in 1997.
- The Convention on Biological Diversity to conserve and sustainably use biodiversity (after OECD, 1998).

2.1.1.2.11 Overall

Thompson and Pretty (1996) reported from studies in Kenya that mobilisation of the community, support for local groups, committed local staff, interdisciplinary collaboration with other departments for planning and implementation at the holistic catchment scale all lead to increased agricultural productivity. In addition, this holistic approach leads to diversification into new enterprises, reduction in resource degradation, enhancement of water resources, improvement in the activities of local groups and independent replication of project interventions to neighbouring communities in Kenya. In order to generate information on the effectiveness, efficiency, appropriateness and ultimate sustainability of a system and to monitor changes in sustainability, indicators of these factors need to be carefully selected (Gorrie, 1999).

The above-mentioned factors are important but not necessarily the only ones affecting sustainability of agricultural systems. There could be some other factors more important in particular environmental and socio-economic niches. The importance of any of these factors may not necessarily be the same over time and space, because of the complexity and dynamic interaction between different aspects of agricultural systems.

2.1.1.3 Indicators of sustainable agriculture

Indicators are datasets that provide a simple and reliable basis for measuring change or performance. An indicator is a chosen function which shows change over time (Riley, 1999). Indicators can measure the efficiency, effectiveness and appropriateness of any intervention. Indicators quantify change, identify processes and provide a framework for setting targets and monitoring performance (Crabtree and Bayfield, 1998). An indicator can be both quantitative (e.g. productivity, kg/ha/yr) and qualitative (e.g. preference analysis), or an index (formed from combination, weighted or otherwise, of collected data, such as a soil fertility index) (Riley, 1999). Thus indicators are tools for both policy planning and communication (de Kruijf and van Vuuren, 1998).

Indicators monitor and assess conditions and trends on national, regional and global scales; compare situations; assess the effectiveness of policy-making; mark progress against a stated benchmark; monitor changes in public attitude and behaviour; ensure understanding, participation and transparency in information transfer between interested and affected parties; forecast and project trends; and provide early warning information (Hammond *et al.*, 1995; Walmsley and Pretorius, 1996 as cited by Walmsley, 2002).

Indicators are signposts that can guide the way to destinations. They provide information about current status, progress trends, pressure points, effect of interventions, areas requiring attention, and milestones (achieved or not). Traditional economic indicators (such as consumption, savings, investment) alone are insufficient to provide real measures of progress, so they should be complemented by environmental and social indicators (Bie *et al.*, 1997). By combining biophysical, economic and policy-related information, indicators can demonstrate how well a programme is progressing (or not) towards sustainable development (Tschirley, 1996; UN, 1999).

It is essential to work out the threshold values of an indicator in order to be able to describe sustainability in tangible terms (Lewandowski *et al.*, 1999). Threshold values are the limits that should not be exceeded if irreversible changes within a system are to be avoided. Threshold values measure change in quantitative terms: “critical loads” or “critical levels” are examples of such threshold values (Lewandowski *et al.*, 1999). Indicators can be further aggregated to form indices that can be used as generic indicators. Highly aggregated indices are essential in developing macro-policy and monitoring progress (Chang and Yu, 2001).

Agricultural sustainability, by nature, is a long term, complex, multi-faceted issue (Gorrie, 1999). The three dimensions (environmental, social and economic) of sustainability interact with each other in a dynamic fashion but need to be maintained in some kind of equilibrium (Tschirley, 1996). Chapter 10 of Agenda 21 stressed the need for an integrated approach to land resources planning and management (Agenda 21, 1992). So any programme aimed at sustainable agricultural development requires a careful selection of indicators to measure the successes made in different components of the system and cross-cutting issues over time. The periodic checking of programme indicators provides opportunities to terminate wasteful efforts and divert more efforts to the activities effectively contributing to programme objectives.

Carefully selected and effectively used indicators can indicate change and flag important conditions and trends that can help in development planning and decision-making (Tschirley, 1997). However, indicators selected without due care may provoke disagreement and debate among the stakeholders. Additional work in partnership with farmers is required to solve any problems identified and achieve sustainable improvements (Shaxson, 1997).

Various types of indicators/tools/frameworks have been developed to generate information regarding sustainable development (Halpern, 1993; Cai YunLong and Smit, 1994; Benites *et al.*, 1997; Brinkman, 1997; Dumanski and Pieri, 1997; Faures, 1997; Oldeman, 1997; Wattenbach and Friedrich, 1997; CSD, 1998; de Soyza *et al.*, 1998; Bouman *et al.*, 1999; UN, 1999; CSD, 2001). The indicator development process is still in an evolutionary phase as development of new tools and frameworks and modification of old tools and frameworks are on-going.

2.1.1.3.1 Criteria for selecting sustainable agriculture indicators

Indicators are tools for planning at the beginning and measuring the impact at the end of programme, so they must be selected carefully so that these objectives can be achieved. Indicators need to be developed according to perceived applications (Dumanski and Pieri, 1997). It is easy to select a list of indicators; however, it is difficult to find an appropriate one (Custance and Hillier, 1998 as cited by Riley, 1999) and relying on inappropriate indicators may result in the generation of inadequate and/or incorrect, inappropriate information. Therefore good indicators should have the following characteristics:

- Sensitive to change and respond predictably to variations in management (Benites *et al.*, 1997; de Kruijf and van Vuuren, 1998; Cornforth, 1999).
- Theoretically well-founded and scientifically valid (de Kruijf and van Vuuren, 1998; Cornforth, 1999).
- Influence the area of concern in a predictable way, either through a functional relationship or through threshold values (Cornforth, 1999).
- Correlate well with ecosystem processes (Cornforth, 1999).
- The selection of indicators depends on the cost incurred and the perceived value of information produced (Benites *et al.*, 1997; Crabtree and Bayfield, 1998); changes should be easy to measure (Cornforth, 1999).
- Indicators must be predictable (Tschirley, 1997).
- Simple in concept (Cornforth, 1999), simple, reliably determined by the farmer and relatively easy to verify (Lewandowski *et al.*, 1999), clear in content (de Kruijf and van Vuuren, 1998), readily understandable (Hammond *et al.*, 1995), and unambiguous (Benites *et al.*, 1997).
- Accessible to both specialists and land managers (Cornforth, 1999).
- Components of existing data sets (Cornforth, 1999).
- Able to support national policy decisions (Cornforth, 1999); indicators should be policy relevant to address the primary concern of the target area (Tschirley, 1997; de Kruijf and van Vuuren, 1998).
- Accepted internationally (Cameron *et al.*, 1996 as cited by Cornforth, 1999).
- Technically measurable (Tschirley, 1997; de Kruijf and van Vuuren, 1998), consistent and objectively measurable (Benites *et al.*, 1997).
- Appropriate to scale (in time as well as geographically) (de Kruijf and van Vuuren, 1998).
- Have a wider significance than their immediate meaning (de Kruijf and van Vuuren, 1998).

OECD (1993) grouped the selection criteria under three different headings, i.e. policy relevance and utility for users, analytical soundness and measurability (Walmsley, 2002). Indicators need to be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) (Schomaker, 1997). People have their own distinct values, so a good indicator may be unique to people, location, cultures and institutions (Chang and Yu, 2001). Several reports provide further information about criteria for the selection and development of indicators (OECD, 1993; Bakkes *et al.*, 1994; EPA, 1994; WRI, 1994).

2.1.1.3.2 Use of indicators

Different types of indicator are being used at different levels (global, regional, national, district and local). Farm level indicators may not be relevant at national or regional levels, as farm level information may not be representative of larger geographical areas, such as a country or region (Riley, 1999). At national level, the indicators are chosen to help policy makers reach decisions, while at district or unit level the indicators are chosen to meet site-specific performance (Bie *et al.*, 1997). Different indicators may be appropriate for different land types. Benites *et al.* (1997) suggested dividing heterogeneous areas into homogeneous zones and using different indicators appropriate to different zones. Alternatively, a generic index may be appropriate and appealing to policymakers as a quick and easy way to evaluate change. However, it cannot provide detail on the variety of multidisciplinary information embedded within it, so may not be suitable for considering mitigating action (Riley, 1999).

A variety of broad indicators is used to assess the sustainability of integrated systems (e.g. catchments), where the interaction of complex and interrelated factors plays a vital role in system sustainability and a holistic assessment is required. Thompson and Pretty (1996) used diverse types of indicators, most of them broad in nature, which could be the reason for the reported difficulty in quantitative assessment. This reveals that, while substantial work has been done in the development of indicators of sustainable development (CSD, 1998), considerable work still remains in developing simple and easily measurable indicators. Particular focus is required on developing a simple and easy methodology for the quantitative assessment of broad and interrelated developmental issues.

In agricultural research, a system is considered to be sustainable if its total productivity does not decline. Therefore, productivity (the ratio of the value of all outputs to the value of all economic and environmental inputs and normalised to remove changes in price) indicators have been adopted by several CGIAR centres (Dumanski and Pieri, 1997) and affiliated National Agricultural Research Systems (NARS). Traditional environmental indicators often ignore human and institutional performance, which are critical factors for the success of sustainable intervention, focussing instead on pesticides and fertilisers, crop productivity and land conservation (Tschirley, 1997).

Farmers have their own traditional methods to evaluate and/or assess a system. For example, farmers in Costa Rica used indigenous indicators for determining reduction in soil erosion (Bhuktan *et al.*, 1994 as cited by Benites *et al.*, 1997), some of which were:

- Plants growing more uniformly.
- Contour walls becoming smoother without slumping during the rainy season.
- Land stripes on the contour becoming flatter.
- Water flowing out of field and water in nearby creeks being fairly clear, in contrast to muddy conditions in the past.
- Stones or gravel no longer visible on the soil surface.
- Decreased frequency of landslides and contour wall slumps.
- Sticky soils becoming more friable, absorbing more rainwater, reducing the speed of surface run-off.
- Increase in topsoil depth.
- Fewer sediments in contour canals, soil traps and checkdams.
- The soil getting darker, softer, water infiltrating more easily and the carabao (water-buffalo) not getting so tired when ploughing.

2.1.1.3.3 Methodological issues in assessing project effectiveness

Despite the priority given to the development of indicators, given the current state of progress, there is no entirely satisfactory methodological approach for the assessment and evaluation of sustainable agricultural practices. However, maintaining productivity and the ability to function (i.e., the regenerative power and buffering capacity) of the various ecosystems should be the yardstick for assessing the effects of different practices in agricultural crop production (Lewandowski *et al.*, 1999). The methodologies used by aid agencies to monitor and evaluate their projects range from rigid frameworks, involving pre-implementation specification of objectives and indicators, to flexible process-based approaches, where indicators are determined during the project (Riley, 1999).

The assessment of impacts is generally carried out during the project period or immediately after the project (e.g. SUAS, 1990; AusAID, 1999a; AusAID, 2000). However, the adoption or adaptation of project recommendations by the local community generally takes place some time after project completion. In such a situation, the determination of sustainability is only possible if the monitoring programme can be carried out after project termination (Riley, 1999).

Many impact assessments have been accomplished based on the results of plot studies (Thompson and Pretty, 1996), since a plot was generally perceived as representative of a large catchment, where effects would impact on a wider scale. Empirical evidence has contradicted this convention and questioned the validity of plot-scale assessments (GTZ, 1991; Fernandez, 1993; Thompson and Pretty, 1996)

Schomaker (1997) argued that most of the assessment work was conducted on an isolated, scientific case study basis, under fewer resource constraint conditions and using very site-specific methodologies. Methodologies developed under such conditions have poor replicability, are site-specific and thus not widely applicable, not realistic in terms of resources (time and cost) and practical applicability within Government Organisation (GO) or Non-governmental Organisation (NGO) structures, and unsuitable to provide an overall picture for larger areas. Moreover, differences exist in the type of data being collected and methodology of collection. Generally, data are collected as routine work, even sometimes without clear reasons for collection, which has adversely affected data quality and posed difficulties in data analysis, aggregation and comparison.

In conclusion, much work on indicator development and testing has been accomplished during the last decade. These indicators have to be implemented under diverse situations and for diverse purposes in the future. Technical assistance for this implementation, encouragement of sharing and collaboration and organising workshops to accelerate further advances will be major foci (CSD, 1998). Human resource development, through appropriate training for scientists and farmers, will be necessary for consistency and information reliability (Riley, 1999). Development of a set of core indicators common to projects will be essential for reliable aggregation of information useful in making policy decisions (Riley, 1999). At present, knowledge and understanding of the links and interactions within and among different ecosystems is limited. Therefore, future research activities should also concentrate on studying the interdependencies within and among ecosystems, to gain a better understanding of the effects of incoming loads on the sustainability of whole systems (Lewandowski *et al.*, 1999).

In future, the applicability, adoption or adaptation of any development intervention aimed at improving sustainability will also have to be assessed considering the socio-economic context of farming households. SUAS (1990) reported that the applicability of technical research must be assessed in terms of local constraints, including credit situation, returns to labour, access to necessary capital, economic efficiency in using of available land, economic returns and cost-benefit analysis of any new or adapted technology.

2.1.2 Technologies for improving the sustainability of cropping systems

A number of technologies have been developed and used in S.E. Asia for improving the sustainability of cropping systems. Studies are being conducted on increasing the efficiency of both specific components and whole systems in order to generate technologies to improve the sustainability of agricultural systems. There is an increasing emphasis and focus on the system-wide approach. In this section, however, only those technologies which are relevant to the case study to be presented in the following chapters have been reviewed.

2.1.2.1 Contour cultivation

This involves growing crops in rows parallel to the contour lines (van Keer *et al.*, 1998). In contrast to downslope, the main aim of contour cultivation is to create an obstruction to reduce the speed and erosivity of runoff water and thereby reduce soil, water and nutrient erosion. Even simple contour mulch lines act as buffer strips against soil and water movement (van Keer *et al.*, 1998). Landslides and soil and water erosion are indicators of unsustainability (Dumanski *et al.*, 1991a).

Bhatia and Choudhary (1977) reported that contour cultivation increased jowar (sorghum) and barley yields by 25 and 15%, respectively, without fertilisers and 29 and 26%, respectively, with fertilisers. Annual soil loss from a plot with a contour hedgerow was 30% less compared to conventional up-and-down cultivation in vegetable production systems in the Philippines (Poudel *et al.*, 2000). Similarly, the use of contour cultivation on slopes of 4-6° reduced soil loss by up to 50% (Neal, 1963).

Contour ridge tillage is the improved version of contour tillage. Contour ridge tillage has greater buffering effects against soil, water and nutrient losses and can retain runoff, decrease soil and nutrient losses and increase soil and water utilisation, thereby increasing crop yield (Zhang and Liu, 1993 as cited by Wang ShuHui, 2003). Maize yield was increased and its economic return was improved in sloping uplands of Yunnan Province simply by replacing downslope cultivation with contour cultivation (Fullen *et al.*, 1996; Wang ShuHui, 2003). Milne (2001) reported a significant reduction in soil loss with the use of ridge contour cultivation systems in uplands with 3° and 10° slopes in Yunnan. Similar results were presented by Barton (2000).

In an effort to develop conservation-oriented watershed management strategies in the Wangjiaqiao watershed in the Three Gorges Area of China, Shi *et al.* (2004) found that contour tillage and contour farming with a seasonal no-till ridge were most effective in reducing soil loss rates. In addition, Gangcai Liu *et al.* (2000) reported that contour tillage with a seasonal no-till ridge was significantly more effective than contour tillage alone in reducing runoff.

Thapa *et al.* (1999) studied soil loss from four different tillage systems: 1. contour mouldboard ploughing in an open field (MP-open); 2. contour ridge tillage in an open field (RT-open); 3. contour mouldboard ploughing plus contour natural grass barrier strips (MP-strips); 4. contour natural grass barrier strips plus ridge tillage (RT-strips). They found that compared to MP-open, soil loss was reduced by 30%, 45% and 53% in RT-open, MP-strip and RT-strips, respectively. Both ridge tillage and natural grass barrier strips reduced soil displacement, soil translocation flux and tillage erosion rates.

Contour ridge is equally effective in reducing soil and water losses from horticultural farmland. The use of contour ridge planting in cabbage and cauliflower trial plots reduced soil loss (9.9 t/ha) compared to plots without contour ridges (15 t/ha) (Rodriguez and Fernandez de la Paz, 1992). Up-and-down cultivation appeared to be most erosive in a rozelle (*Hibiscus subdariffa*) farming system in Thailand, while contour cultivation emerged as the most effective practice (Sombatpanit *et al.*, 1995).

Thus contour cultivation can reduce landslide and soil and water erosion compared to downslope cultivation practices under a variety of farming situations and crop combinations leading to conservation of topsoil and soil fertility. This suggests that contour cultivation improves sustainability compared to downslope cultivation practices.

2.1.2.2 Minimum or no tillage

Reduced/minimum/no-tillage systems are also described collectively as conservation tillage (Lal *et al.*, 1990), in which the soil surface is disturbed as little as possible during planting operations (Pretty, 1995). Typically, at least 30% of the residues from the previous crop is left on the soil surface (Stinner and Blair, 1990). This system helps in reducing soil and water erosion thereby contributing towards improved sustainability. Normally, crop residues are incorporated into the soil in conventional tillage as a result of turning the soil. In minimum tillage, large amounts of crop residue remain on the soil, reducing run-off, soil erosion and nutrient loss. Minimum tillage may also reduce the energy consumption involved with cultivation (thereby reducing production costs) and soil erosion (Edwards, 1990; Lal *et al.*, 1990; Logan, 1990). This tends to create a more natural soil structure, which can improve both drainage and water retention, depending on soil type (Edwards, 1990). Minimum tillage systems are appropriate for soils with coarse textured surface horizons, good internal drainage, high biological activity of soil fauna, favourable initial soil structure and a friable consistency over a wide soil moisture range, where there are adequate quantities of crop residues for mulching (Lal, 1986).

Minimum tillage is reported to reduce erosion by as much as 90% (Langdale *et al.*, 1978; Mannering, 1979; Crosson, 1981 as cited by Lal *et al.*, 1990). However, the performance of crops under minimum tillage varies with climatic and soil properties and management practices. Generally, minimum tillage has been reported to be more effective when combined with the use of mulch or other organic matter (Lal, 1976; Paningbatan *et al.*, 1995; Ghuman and Sur, 2001). A common problem with minimum tillage systems is the control of weeds and the control of pests and diseases which over-winter on the crop residues.

2.1.2.3 Mulching

Any material (biodegradable plant residues or non-degradable polythene sheets) spread or placed over the soil to cover the soil surface partially or fully is known as mulch. The main aims of covering the soil surface are to protect the soil from erosion, conserve soil moisture, increase or maintain temperature, increase soil fertility, reduce surface sealing and crusting, suppress weed growth and control insects and soil borne diseases (Lal, 1986; Pretty, 1995; Tolk *et al.*, 1999; Porter, 2002; Wang ShuHui, 2003). Two types of mulches are commonly employed in S.E. Asia. The use of natural mulch (for example, crop residues, grasses, leaf litters, farm yard manure, husk, sawdust, pruned branches/twigs, wood chip, tree bark, ash) is an age-old practice, mainly used in subsistence farming systems. Synthetic or non-degradable mulch (for example, plastic sheet, stone/gravel) is generally used for specific purposes in commercial production systems.

Some studies have reported straw mulch as a measure to conserve soil and water, improve crop yield and restore soil fertility. Aina (1981) reported an increase in maize yield by 63% due to mulching compared to no mulch treatments. Mulching early (during the first 7 days after planting and for a long duration (>6 weeks) increased maize yield. Straw mulch has also been reported to decrease maximum soil temperature, maintain soil moisture at the surface and increase maize yield (Lal, 1974; Gajri *et al.*, 1994).

Adams (1966) reported that the protective action of straw and gravel mulch increased water infiltration by reducing runoff, essentially eliminating erosion. During the drier period of the season, straw mulch reduced soil water losses, improved water availability and increased grain yield (Wu XingMing, 1990; Fullen *et al.*, 1999; Wang ShuHui, 2003).

Maurya and Lal (1981) compared the effect of different types of polythene mulch (black and clear) and straw mulch on various growth parameters and yields of maize and cowpea. Shoot elongation and root density were higher under straw mulch treatments. Black polythene and straw mulch treatments produced greater yields than unmulched and clear polythene treatments. The maximum soil temperature with black polythene was 3-4°C lower than that with clear polythene. Porter (2002) presented similar results. This suggests that mulch material should be selected with the impact of the growing environment on the crop being taken into consideration.

In Yunnan Province, clear polythene is used to improve crop yields, particularly of tobacco, vegetables and maize. A 90% cover of black polythene was effective in conserving soil moisture and increasing maize yield and water use efficiency over the conventional practice, which was attributed to increased soil temperature under polythene (Peng Guofang, 1990 as cited by Huang BiZhi, 2001).

Laboratory evaluation of the effectiveness of different mulch materials demonstrated that mulches that were porous and capable of holding and storing water (such as straw, bark, burlap and jute), produced reduced runoff depths, lower sediment concentrations and lower erosion rates than mulches which could not absorb water, such as rocks (Jennings and Jarrett, 1985).

2.1.2.4 Crop rotation

This is a process of changing the types of crops grown on a particular piece of land from season to season, which may also include a fallow period (van Keer *et al.*, 1998). Crop rotations are practised to improve or maintain soil fertility, reduce erosion, reduce the build-up of pests, spread the workload, reduce risk of weather damage, reduce reliance on agricultural chemicals and increase net profits (Peel, 1998). Thus crop rotation on one hand reduces soil, water and soil fertility losses from agricultural land and on the other hand improves crop productivity, contributing to the sustainability of the agricultural system. Increases in the extent of crop rotation are considered an indicator of sustainability of agricultural systems (Dumanski *et al.*, 1991a). Crop rotation can also mean that succeeding crops, although similar, are of a different species, subspecies, or variety to the previous crop. However, this approach would be less effective in achieving the above-mentioned benefits.

Leguminous crops are one of the preferred choices to include in crop rotations due to their ability to improve/maintain soil fertility and hence yield of the succeeding crop. Soybean (*Glycine max*), cowpea (*Vigna unguiculata*), pigeon pea (*Cajanus cajan*), pea (*Pisum *sativum*), bean (*Phaseolus* spp.), groundnut (*Arachis hypogaea*), broad bean (*Vicia faba*), dolichus bean (*Dolichus lablab*) are some of the food legumes used in crop rotation. Hulugalle and Lal (1986) reported that the yield of a maize crop grown after pigeon pea was ~ 50% higher than the yield of maize grown after maize.

Garcia-Prechac *et al.* (2004) reported that soil erosion from crop-pasture rotation with minimum tillage was similar to that of natural pasture in Uruguay. This can be considered one of the most efficient technologies for minimising soil erosion, as it is unlikely that soil erosion from any cultivated field can be less than from natural pasture. Crop-pasture rotation systems may be more environmentally sustainable, since fuel and agrochemical usage can be reduced by approximately 50% (Garcia-Prechac *et al.*, 2004). Crop rotation is also effective in reducing plant diseases. Potato diseases (canker and black scurf) were significantly less in 3-year rotations compared to 2-year rotations (Peters *et al.*, 2003).

2.1.2.5 Intercropping

Growing of two or more crops simultaneously on the same piece of land is called intercropping or mixed cropping (van Keer *et al.*, 1998). Typically this is characterised by growing crops with different growth cycles, canopy structures, root systems and nutrient and water requirements simultaneously. An increase in the extent of intercropping is an indicator of agricultural sustainability (Dumanski *et al.*, 1991a).

Intercropping, combined with litter recycling, improved the physical, chemical and biological properties of soil (Manna and Singh, 2001). Water use efficiency for maize and cowpea grown in the same row was greater than that in alternate rows (unpublished information of Hulugalle and Lal, 1984 as cited by Lal, 1986). Pigeon pea can supply water from deeper soil layers to associated maize plants through hydraulic lift (Sekiya and Yano, 2004). This implies that the use of deep-rooted species in intercropping systems can allow shallow-rooted crops to utilise otherwise unavailable water sources deep in the soil layers.

Intercropping is also a means for reducing the level of insect infestation in crops. Pitan and Odebiyi (2001) reported that the level of pod-sucking bug infestation in cowpea was significantly less under a maize/cowpea system compared to a cowpea monoculture. Bug infestation was not reduced when the cowpea stand was exposed because of early planting (due to immature maize) and late planting (due to drying maize). This implies that the bug infestation was low only while the intercropping system was optimised.

The importance of intercropping systems is widely recognised, particularly in densely populated regions, because of the stabilising effect of intercrops on food security and enhanced land use efficiency (Snapp *et al.*, 1998). However, the benefits of mixed cropping are generally greater under adverse conditions with low inputs than in regions of few constraints and high inputs (Lal, 1986). Intercropping also has implications for the harvesting method that can be used – generally manual harvesting increases the scope for mixed cropping.

2.1.2.6 Alley cropping

This is another form of intercropping in which annual crops are grown between two contour hedgerows of trees or shrubs. Alley cropping can also be considered as another form of agro-forestry, because of the use of tree species in the hedgerow.

Contour hedgerow is a type of alley cropping considered to be an effective and low-cost method of erosion control for cultivated sloping upland. Hedgerows have the potential to mitigate yield variability of crops in at least two ways: firstly, by improving moisture retention during low-rainfall periods, and thereby reducing moisture stress and enhancing plant growth; secondly, by reducing overland flow and thereby reducing associated crop damage during high rainfall periods (Shively, 1999). Thus alley cropping helps in improving/maintaining crop production and reduces soil, water and soil fertility losses and contributes to the sustainability of agricultural systems.

The use of hedgerows of *Tephrosia candida* and mulching with *Tephrosia* biomass effectively controlled nutrient losses from soil erosion in sloping uplands in Vietnam (Hoang Fagerstorm *et al.*, 2002). However, in field experiments conducted in semi-arid tropical highlands of Kenya, Mathuva *et al.* (1998) reported that there was no yield advantage in maize from hedgerow intercropping, because of the competition between hedgerow species and the crop. Similar results have been presented by Dakora and Keya (1997) in an attempt to evaluate traditional cropping systems in sub-saharan Africa. The authors reported that crop rotation involving legume and cereal monocultures is far more sustainable than intercropping. McIntyre *et al.* (1997) reported similar results in semi-arid environments in Kenya.

Challenges to the adoption of perennial system technologies include establishment costs, resource competition and delayed benefits (Snapp *et al.*, 1998). Similarly, Tang Ya *et al.* (2003) reported that farmers' adoption of hedgerow intercropping systems in China was unsatisfactory in the past, despite their effectiveness in soil conservation and soil fertility improvement. This was due to lack of a visible and direct income from the technology. Nelson and Cramb (1998) investigated the economic incentives for farmers in the Philippine uplands to adopt hedgerow intercropping compared to traditional open-field maize farming. They found that there were strong economic incentives for farmers to reject hedgerow intercropping over a limited planning horizon of about five years. Nelson *et al.* (1998) postulated that insecure land tenure limited the planning horizons of upland farmers, and high establishment costs reduced the economic viability of hedgerow intercropping relative to continuous and fallow open-field farming in the short-term. This was because the benefits of sustained yields were not realised rapidly enough to compensate for high establishment costs. This indicates that adoption of improved practices can be limited where longer-term investment is required and the cost of adoption is higher than losses resulting from rejection. Alegre and Rao (1996) presented similar results in a study conducted in the humid tropics of Peru. They reported that soil and water losses were reduced, soil nutrient status was increased and soil physical conditions were improved by contour hedgerow intercropping compared to monoculture. However, there was no yield advantage during the first five-year period.

The selection of crop species should be made carefully in order to achieve the successful implementation of alley cropping. Tonye and Titi-Nwel (1995) reported that in maize/groundnut with *Leucaena leucocephala* in the alley, groundnut yield was improved in alley crops compared to non-alley conditions, but decreased when the crop was fertilised with chemical fertiliser, particularly nitrogen-based fertilisers. In contrast, maize yield was better when chemical fertilisers were supplemented. Increased shading due to the increased vigour of maize in response to chemical fertiliser and/or excessive vegetative growth of groundnut at the expense of pod development because of large amounts of nitrogen fertiliser could be the reason for low groundnut yields. This highlights the need for selection of suitable crops for different management conditions in alley cropping.

Poudel *et al.* (2000) reported that farmers in the Philippines did not like the conventional hedgerow species because of reduction in arable land area, shading effect on the main crop, requirement of regular maintenance, lack of immediate economic return and unavailability of planting material. So farmers tested alternative high-value hedgerows of asparagus (*Asparagus officinalis*), pineapple (*Ananas comosus*), pigeon pea (*Cajanus cajan*), lemon grass (*Cymbopogon flexuosus*) and tea (*Camellia sinensis*) in the contour. The farmers' interest in high-value hedgerow species indicates their quest for more economically-viable hedgerow technologies. Despite the effectiveness of currently available technologies in terms of environmental impacts, they were not effective enough (and not appreciated by farmers) in improving farmers' incomes. This indicates the need for more research in identifying more suitable hedgerow technologies.

A grass strip is another form of alley cropping. Narrow strips of dense perennial vegetation are planted along contours between the cropped land in the alley cropping system (Dabney *et al.*, 1999; Thapa *et al.*, 1999).

2.1.2.7 Agro-forestry

This is an agricultural land use system which deliberately combines trees with arable crops and/or livestock (van Keer *et al.*, 1998). Growing annual crops with tree crops, plantation crops, and pastures are examples of different forms of agro-forestry. The definition used by the International Center for Research in Agroforestry (ICRAF) is more specific, which is stated as *'situations where woody perennial species and annual crops (and/or livestock) occupy the same unit of land'* (Garforth *et al.*, 1999). In an agro-forestry experiment, Lehmann *et al.* (1998) found that tree roots grew deeper during the drought periods, resulting in significantly less soil water depletion from the topsoil between the two tree rows. The soil moisture 'unused' by trees was utilised by the annual crops. Such complementary use of resources by tree and crop is the key for the success of agro-forestry technology.

2.1.2.8 Use of organic manure

This refers to any material that is derived from living organisms that can be used to improve soil fertility and quality. Compost, farmyard manure, mulches and green manures are the main sources of organic manures. Organic manures are good sources of plant nutrients and one of the most important factors being used for sustaining subsistence farming systems in Asia, Africa and Latin America. Soil organic matter is an important indicator of soil health, which can be improved by adopting conservation farming practices, such as adding compost to soils, planting cover crops, reducing tillage and practicing crop rotation (The Food Alliance, 2001).

Organic matter influences many soil properties, such as soil fertility, structure and profile development (Stevenson, 1994; Morgan, 1995; Wood, 1995). Application of cattle manure, 12.5 t/ha for 3 years and 37.5 t/ha in the first year, increased organic C by 10 and 38%, respectively, in the 0-10 cm soil layer in Zimbabwe (Nyamangara *et al.*, 2001). In addition, the application of manure also improved aggregate stability and the readily available water (RAW) capacity of soil. Similarly, Aggarwal *et al.* (1997) found a 10-20% increase in soil fertility status (N and P availability, organic matter, enzyme activity) due to incorporation of residues of cluster bean (*Cyamopsis tetragonoloba*), mung bean (*Vigna radiate*), pearl millet

(*Pennisetum glaucum*) and farm yard manure (FYM) in India. In addition, cluster bean residues and FYM increased pearl millet grain yield by 0.1-0.2 t/ha compared with no residue.

Pagliai *et al.* (2004) reported that application of both compost (10-40 t/ha) and manure (10 t/ha) improved soil porosity and soil aggregate structures. Pore space and soil aggregates are measured to quantify soil structure, which is one of the most important soil properties affecting crop production. Even a small cover (0.5-5.0%) of dung deposit was effective in reducing soil crusting and increased infiltration in the semi-arid Sahel of West Africa (de Rouw and Rajot, 2004).

Soil organic carbon (SOC) is an important soil quality indicator. Continuous cropping results in the decline of SOC, although the rate and magnitude of decline depends on climate and soil. This can be altered by appropriate soil management practices (Reeves, 1997). Tianyun Wu *et al.* (2004) reported that total soil organic carbon decreased on continuous cultivation in the Loess Plateau of China. The decrease was more pronounced in erosion-prone sloping land compared to flat areas. However, the application of 75 t manure/ha/year for 20 years increased total organic carbon (TOC) in the surface soil to the level of native sods. The authors concluded that the adoption of soil conservation practices (such as reduced tillage) along with the application of manure and crop residues should maintain soil organic matter quantity and quality in the Loess Plateau.

Farmers are generally well aware of the benefits of organic manure, so in many societies they try to maximise manure production. Tanner *et al.* (2001) carried out group interviews, involving preference ranking and matrix scoring exercises in upland areas of Java to understand biophysical and economic rationales for labour-intensive (and therefore expensive) backyard animal rearing systems. The study revealed that farmers place value on the inclusion of animal wastes, particularly urine, into compost. Moreover, in rainfed areas, manure production ranked similarly to meat production as important outputs from sheep rearing.

2.1.3 Development projects

Development strategies of international aid agencies and regional/national organisations working within developing countries have undergone a series of notable changes over recent few decades, particularly since the 1950s. Despite various changes in planning and implementation strategies, development efforts largely remained ineffective in achieving their objectives (Ellerman, 2002). This is evident from the continuation of widespread decline in agricultural and other associated ecosystems (Uphoff, 2002; Röling, 2005). In the first part of the following sections, the evolution of development projects, their strategies, and innovation systems are discussed. In the second part, a review of the sustainable development projects and programmes implemented in SE Asia are presented.

2.1.3.1 Development projects, their evolution and evaluation

By 1970, development intervention through the project approach became popular, particularly in developing countries. A project is defined as ‘a planned undertaking designed to achieve specific outputs/results within a given budget frame and within a specified period of time’ (Norwegian People's Aid, 2003). A large proportion of international development assistance for developing countries adopted the project approach, as both donors and recipient governments preferred this methodology. This was because donors considered that accountability could be ensured and special administrative arrangements could be achieved through the project approach. Local governments also preferred this approach as projects allowed community-based development intervention. This enabled local government to reward the supporter and neutralise opposition (Shepherd, 1998). The project concept originated in western industrial societies, with the following basic elements:

- *Disciplined conceptual disaggregation of complex, or ill-defined problems into discrete tasks for which resources can be mobilised and targeted.*
- *Specific time boundaries within which projects begin and end according to a funding schedule and work plan.*
- *Pre-programmed activities in which the resources, contracting, procurement, training and anticipated outcomes are all planned or ‘designed’.*
- *Applied economic and systems analysis used in the appraisal of a project idea to determine whether it is economically viable or rational according to other technical criteria.*
- *Standardised reporting procedures for monitoring, control and evaluation* (Morgan, 1983 as cited by Shepherd, 1998).

A major proportion of aid funds was raised and channelled through the project approach (Shepherd, 1998). The project approach is framed to answer basic questions about development interventions, for example; ‘why to do’, ‘how to do’, ‘who to do’, ‘to whom to do’, ‘when to do’ and ‘where to do’ the work. In addition, this approach ensures quantification of resources (human, financial and other) required for the outputs (results) expected. Projects allowed innovation, experiment and special conditions, which were difficult to manage in routine on-going programmes (Rondinelli, 1993), so projects remained the preferred approach. In addition, this approach allowed review, reformulation and learning from experiences; however development projects were rarely evaluated and even more rarely publicised (Shepherd, 1998).

Despite the popularity of the project approach, Shepherd (1998) considered the following characteristics to be fundamental problems for the achievement of rural development objectives.

- *Control orientation:* It was believed that current events and various states of resources could be manipulated to achieve a desired objective in a controlled and predictable manner. The search for certainty and control leads to the search for authoritative organisation and the control orientation is directly the opposite of many common progressive rural development objectives.

- *The project cycle and project rationality:* The project cycle includes different phases, from pre-planning (i.e., identification/realisation of problem) to post-implementation (i.e., evaluation) and a variety of more or less complicated and systematic methods are associated with each stage. Greater emphasis was given to improving planning and design skills with very limited consideration to improving managerial and implementation skills; as a result these skills are lacking, particularly in poorer developing countries.

- *The financier-economist's project:* Projects were originally initiated by engineers to implement construction work in the western world. This approach was transferred to other areas of expertise in developing countries. But there were fundamental differences in the ability of society to question monitoring, evaluation and improvement. Based on economic evaluations, western society was able to question developers and protect against undesired consequences. However in developing countries, local economists either did not exist or generally played a subordinate role to financiers (policy makers/donors) and lacked the opportunity to work independently or have the ability to question the financiers.

Despite such concerns, the project concept offers many comparative advantages to the organisations involved (particularly donors and governments) and there is no effective alternative developed yet, so donors and governments are likely to continue using the project approach for translating policy into action programmes (Rondinelli, 1993).

‘Blueprint’ projects were less successful in addressing diverse problems associated with local situations. A ‘blueprint’ project is a detailed and rigid plan of a project, specifying outcome expected, activities to be conducted, resources required and timeframe. The plan is prepared centrally and adopts a top-down approach (Chambers, 1997). The effectiveness of the existing ‘blueprint’ project can be improved by adopting participatory processes, as learning processes and simplifying the analytical and planning methods, so that ordinary rural people can be involved in the project processes (Ellerman, 2002; Rondinelli, 1983; Korten, 1987; Chambers, 1993 as cited by Shepherd, 1998). Studies have shown that flexibility in planning and design and the opportunity to adjust and redesign plans during implementation are key factors for improving the likelihood of project success (Rondinelli, 1993).

2.1.3.1.1 Planning and implementation approaches

In the 1950s and 1960s, systems for planning and implementing development policies considered long range, comprehensive national planning strategies with a centrally controlled top-down approach (Rondinelli, 1993). However, this approach achieved little, except “islands of success” in reducing widespread poverty and thus failed to establish the foundation for sustained economic growth and human development (Rondinelli, 1993).

Rationalistic approach

By 1970, most of the international aid agencies had adopted a rationalistic approach to planning and decision making, which was founded on the perception that complex social problems could be understood through systematic analysis and solved through comprehensive planning (Lindblom, 1965 as cited by Rondinelli, 1993). It was based on the theory that the problem would be defined concisely through exhaustive analysis and thereby alternatives could be identified, from which optimal and correct policy change could be made (Rondinelli, 1993). Plans were implemented through hierarchical structures of authority and comprehensive systems of rules and regulations. Deviation from the original plan was considered detrimental to achieving development objectives. Planners and policy makers would decide on the course of action, which implementers had to follow. The rationalistic approach was based on the perception that planners and government need strong power planning and management of development activity, which was similar to the conventional approach. The rationalistic approach was clearly reflected in the planning and management methods used by international aid agencies, including the UN, the World Bank and most bilateral agencies, as these organisations gave strong emphasis to the use of comprehensive and systematic analysis for the identification, preparation, appraisal and selection of development projects (Rondinelli, 1993).

During the 1960s and 1970s, the project became the primary means through which governments of developing countries translated their plans and policies into action programmes. The rationale was that comprehensive and detailed development plans would produce desired outcomes only when they could be converted into specific projects that could be designed and implemented efficiently. Thus projects started to play an important role in the political economy of developing countries (Rondinelli, 1993).

The main objective of projects during the 1970s was to encourage social change, which would help to achieve basic human needs and provide new and improved skills to initiate and sustain development. It was assumed that successful projects would be able to produce resources and foster development. During this period the work of international funding agencies depended to a great extent on project management methods and procedures that were adopted from private organisations involved in physical construction projects and government agencies in western countries. The project management methods included cost-benefit analysis, linear programming models, network scheduling and planning/programming/ budgeting systems (Rondinelli, 1993).

During the 1970s, however, development assistance policies focused increasingly on alleviating poverty, improving agricultural productivity, expanding employment opportunities and providing greater access to social services for more people. This made project design more complex and increased the uncertainty of project success (Rondinelli, 1993). Therefore the focus of the planning, analysis and management methodologies introduced during the 1960s and 1970s was based on efficiency and control. The methodologies were not primarily focused on flexibility, responsiveness and learning. According to Rondinelli (1993), some of the limitations of rationalistic planning and systematic management approach included:

- Detailed and systemic planning that was time-consuming, costly, delayed implementation and was often ineffective.
- Increased inconsistency and uncertainty.
- Increased dependence on foreign experts for planning and managing projects, which made projects unrealistic and inappropriate for local conditions.
- Failure to involve intended beneficiaries in project planning and management.
- Inflexibility and unnecessary constraints on managers.
- Reluctance to engage in evaluation and error detection.

Structural adjustment approach

A structural adjustment approach evolved during the 1980s and early 1990s to reform economic policy, which encouraged the flexibility, experimentation and social learning that were crucial to successfully implementing complex and uncertain development activities (Rondinelli, 1993). However, the approach was based on highly standardised instructions and the rationalistic model, thus the rationalistic theory was still largely in use. The structural adjustment approach focused on the functioning of national economic systems. Macroeconomic theory and econo-mometric models were used to recommend policy changes.

Development policies were rarely implemented following the prescribed course of action. This led to the disparity between principles and practice, which was the driving force for persistent debates over the effectiveness of the conventional methods of development planning and administration (Rondinelli, 1987 as cited by Rondinelli, 1993). This theory also failed to recognise that many economic issues were also political issues and decisions about such issues were made by criteria that could not be easily summarised by mathematical equations (Kamarck, 1983 as cited by Rondinelli, 1993). Structural adjustment policy often failed to consider the effect of social, cultural and political differences on human behaviour.

Adaptive approach

Rationalistic and control-oriented management systems failed to be effective and were not appropriate to cope with the complexity and uncertainty of many development projects. The adaptive approach evolved during the early 1990s as an alternative to rationalistic and control-oriented management systems. An adaptive approach is based on concepts of strategic planning, incremental analysis, experimental design and successive approximation in decision-making. Rondinelli (1993) suggested a four-stage process of project planning and implementation, which could address the developmental problems in experimental, incremental and adaptive ways. The four phases of planning and implementation were:

- *Experimental projects* are generally small-scale, highly exploratory and risky ventures. They generally do not provide quick and direct economic returns, but they can be useful in identifying development problems, appropriate methodologies, choice of interventions and appropriate conditions for project implementation.
- *Pilot projects* are used to test the applicability of innovation from experimental projects in similar other areas, and feasibility and applicability of innovation in new areas. They can be a mini-version of a large-scale programme.

- *Demonstration projects* are implemented to present the advantages of the innovation in comparison to the existing approach.
- *Replication projects* are used to scale-up innovation.

2.1.3.1.2 Changes in development strategy

By the late 1960s, it became clear that capital-intensive industrialisation policies had not been successful in promoting growth and alleviating poverty. Development policy and aid strategy came under scrutiny when various international evaluation missions criticised it as inadequate or inappropriate (Rondinelli, 1993; Fukuda-Parr *et al.*, 2002). Many developing countries and international aid agencies reported that some developing countries realised an increase in aggregate economic growth, but in most cases the benefits of growth did not reach the vast majority of poor people (Rahman, 1993). This widened economic disparity between rich and poor. Some national leaders perceived that political stability and national unity could be at stake if this situation was unchecked. This led to a change in development strategies aiming to increase employment, promote social development, reduce regional disparity and distribute income more widely (Rondinelli, 1993; Fukuda-Parr *et al.*, 2002). Some countries stressed the need for widespread participation in economic activities to accelerate and sustain economic growth. Similarly, international aid agencies changed their strategies for aid to developing countries. For example, in the early 1970s, the US Agency for International Development gave high priority to those development activities in developing countries that aimed to improve the lives of the poorest people and their capacity to participate in the development of their countries. The World Bank diverted its emphasis to loans for multi-purpose, integrated, low-cost, replicable projects designed to benefit the poorest groups, by increasing the productive capacity of small-scale farmers and rural industries (Rondinelli, 1993). Many international aid agencies and governments in developing countries voiced similar aims. In 1991, the Development Assistance Committee (DAC) of the Organisation of Economic Co-operation and Development (OECD) issued a document entitled *Principles for New Orientations in Technical Co-operation*, which called for changes in existing practices. This emphasized the need for local control and long-term capacity development (Fukuda-Parr *et al.*, 2002). As a result, funding agencies/countries started to work with local government and organisations in developing countries to redesign the aid programmes. In the 1990s, the donor community gave high priority to participation to increase the ownership of development activities for government and non-government organisations, civil society and the private sector. The World Bank and International Monetary Fund (IMF) changed their approach from top-down structural development programmes and adopted the participatory process in order to bring local stakeholders into actions for poverty reduction.

2.1.3.1.3 Evolution of development theories

In summary, the history of development theories used in development assistance has witnessed three major evolutionary phases (Rondinelli, 1993).

- *Period I (1950s and 1960s):* During the 1950s, international assistance organisations advised developing countries to adopt industrial development policies from western countries (Fukuda-Parr *et al.*, 2002). It was assumed that this would accelerate economic growth in developing countries and that the trickle-down and spread effect, resulting from economic growth, would alleviate poverty. During the 1960s, development assistance strategies attempted to eliminate problems for economic growth by redistributing productive assets, controlling population growth and increasing productive capacity in weak sectors of developing countries.
- *Period II (1970s):* During this period, international assistance organisations gave emphasis to the equitable distribution of economic growth. The concerns of international assistance organisations and governments of developing countries focused on the rate and pace of economic output and distribution of benefits. International assistance was aimed at providing basic human needs for the poorest people and improving their living standards.
- *Period III (late 1970s and early 1990s):* During the 1980s and early 1990s, international assistance organisations changed their strategies to restructure the economies of developing countries. They provided adjustment loans to increase export production, liberalise trade, decentralise government and privatise state-owned enterprises. Increasing private sector productivity received higher priority from international assistance organisations during this period, rather than meeting the basic needs of the poor.

Efforts to seek more effective strategies continued. During the 1990s and early 2000s, development assistance organisations moved away from the top-down approach to a participatory process. Many international development assistance organisations started to realise that the natural process triggering and sustaining prosperity in developing countries would be ‘development as transformation’ rather than ‘development as displacement’ (Fukuda-Parr *et al.*, 2002). The principles of ‘development as transformation’ are based on promoting locally developed processes and building on local knowledge and capacities to achieve national goals and aspirations. Thus the strategy of development assistance is moving away from the ‘direct approach of conventional money-based and knowledge-based aid’ to an ‘indirect approach based on respect for the autonomy of the local organisations and countries, starting from where they are and seeing the world from their eyes' (Ellerman, 2002).

2.1.3.1.4 Innovation systems and farmers' involvement in technology development

Conventional approaches have been generally unsuccessful in achieving agricultural research and development goals in developing countries (Cornwall *et al.*, 1994; Freudenberger, 1994; Shah, 1994). This has triggered the invention of more appropriate alternative strategies for research and development. As a result, farmer participatory approaches have been widely used over the last two decades. Thus the innovation of new strategies and approaches has triggered a shift in the research and development policies of international aid organisations, non-governmental organisations and some governments in developing countries.

Innovation is regarded as 'any new knowledge introduced into and utilised in an economic or social process' (OECD, 1999). Innovation takes place through the process of discovery (emergence of concept or results) and development (dissemination, scaling-up, commercialisation and integration of concepts and/or results with other elements of the production process (Sunding and Zilberman, 2000). An innovation system is a network of organisations within an economic system that is directly involved in the development, diffusion and use of scientific and technological knowledge, as well as organisations responsible for the co-ordination and support of these processes (Dantas, 2005). 'Innovation emerges from interaction among stakeholders in the theatre of innovation' (Engel and Salomon, 1997 as cited by Röling, 2005). Thus, innovation is the result of interactive processes between stakeholders. All the stakeholders function in a web of interrelationships and none work in isolation. The innovation systems approach is becoming popular for studies of how society generates, disseminates and utilises knowledge, and how such systems can be strengthened for greater social benefit (Spielman, 2005). The focus of the technology generation process in the conventional approach is primarily on research, but the innovation systems approach views research as only one element of the system. Thus, innovation systems mark a shift from conventional approaches.

There are no blueprints for innovation, rather innovation systems provide a series of guidelines fostering linkages and encouraging a continuous feedback between stakeholders (Dantas, 2005). The effectiveness of an innovation system depends on the critical mass of relevant players and the interdependence between players. A summary of different agricultural research and development approaches in the context of innovation systems is presented below.

Agricultural research and development received great emphasis after World War II. Since then models and approaches for agricultural research and development have been implemented that differ greatly in time and space. A *Community Development* approach was used during the 1950s and early 1960s. With the realisation of the failure of the Community Development approach to improve the economic and social well-being of rural people, the focus of developing countries and international aid agencies shifted towards *Integrated Rural Development (IRD)*. In contrast to Community Development, the focus of IRD was narrower with considerable emphasis on improving agricultural production. This coincided with the development of seed and fertiliser technology, which helped in reinforcing IRD during the late 1960s (Hayami and Ruttan, 1985). There was a radical shift in agricultural development approach during the early 1970s from IRD towards meeting the basic needs of the poorest people. The objective of the *Basic Needs* approach aimed at eradicating hunger and malnutrition by 1985 (Hayami and Ruttan, 1985).

The *Farming Systems Research-Extension (FSR/E)* approach evolved during the late 1970s. The FSR/E programme acknowledged the fact that adoption of new technologies, introduced from outside the system, was limited by farm level constraints (Gartner, 1990 as cited by Cornwall *et al.*, 1994). FSR/E emphasised the consideration of farm resources and constraints and the needs of farmers during the design of research programmes. It initiated the evaluation of applied agricultural technologies in targeted geo-climatic and socio-economic situations. Thus, agricultural research extended beyond the boundaries of research stations. In this respect, FSR/E was different from previous approaches. Agriculture was viewed as a holistic system, so a multidisciplinary approach was adopted for research and development activities. This encouraged interactions between researchers from different disciplines, extension workers and farmers in research and development processes. The basic research was conducted in research stations and applied research under farm conditions. The FSR/E approach moved significantly away from the previous crop-focused approaches towards an integrated farming approach. However, it relied primarily on conventional scientists and research approaches, which generally remained insensitive to farmers' indigenous knowledge (Cornwall *et al.*, 1994). In addition, the 'Transfer of Technology' model of extension treated farmers as passive adopters of technology. Thus, farmer participation was generally limited to 'contractual' or 'consultative' modes according to the typology presented by Biggs (1989).

Farmer Participatory Research (FPR) was developed during the 1980s. This approach was designed to work more closely with farmers in on-farm research than FSR/E (Cornwall *et al.*, 1994). It recognised indigenous knowledge (IK) and viewed farmers as experimenters and/or innovators with a ‘collaborative’ or ‘collegiate’ relationship between farmers and researchers being pursued. Models of collaboration between researchers and farmers have been grouped into three different categories (Cornwall *et al.*, 1994).

a. *Model I:* The process relies on conventional agricultural science with the dissemination of simple experimental techniques to farmers. The focus of this approach is on alternative methods rather than methodologies.
b. *Model II:* The process involves the selection of farmers and work with them to improve their capacity. Only farmers who are positive to researchers and collaborate in the research following the scientific standards suggested by researchers are selected. Thus, collaboration between other farmers and researchers is limited.
c. *Model III:* The process focuses on changing roles and responsibilities between researchers, extension workers and farmers with collaboration based on mutual learning as colleagues (Chambers, 1993 as cited by Cornwall *et al.*, 1994).

The second and third models provide radical alternatives to conventional research and extension approaches.

Rapid Rural Appraisal (RRA) and *Participatory Rural Appraisal (PRA)* focus on broader issues of livelihood strategies and consider agriculture as one of several livelihood strategies, while previous approaches viewed agriculture as fundamental. RRA emerged in the late 1970s and involves a range of rapid and cumulative data collection methods. It focuses on cost-effectiveness and multidisciplinarity as key features (Cornwall *et al.*, 1994). A semi-structured checklist is the primary instrument for exploring local situations and perceptions. In this approach, a team of multidisciplinary scientists and extension workers gather information in a conventional way and in consultation with farmers. The information collected is analysed by researchers and extension workers and presented to farmers. Thus farmers have no role in the analysis and interpretation of information. By the late 1980s, the focus changed from rapid collection of information by researchers and extension workers to facilitating farmers in the collection and analysis of their own information. Thus, the role of farmers and researchers/ extension workers was reversed with the approach being termed *Participatory Rural Appraisal (PRA)*. This approach stressed the production of information and development of potential solutions by those whose livelihood strategies were being addressed (Cornwall *et al.*, 1994). RRA and PRA approaches use a range of observation, visualised analysis, group-work and interview methods. RRA and PRA offer a creative and efficient approach to information sharing; however their effectiveness depends on the way the facilitator engages with the local community and gives control to them.

Participatory Action Research (PAR) emerged during the 1970s. PAR recognises the marginalisation caused by 'universal science' by restoring oppressed people's self-respect and voices (Cornwall *et al.*, 1994). This approach focuses on addressing political issues, mainly the politics of inequality. PAR seeks to break the domination of conventional power structures in which ordinary people have no role to play. Thus, it promotes the process of transformation towards independence of poor people who are oppressed and marginalised by conventional power structures. PAR expects researchers and extension workers to work as agents of change and leaders, willing and able to hand over control of the change process (Cornwall *et al.*, 1994).

The *Development Education and Leadership Teams in Action (DELTA)* approach was developed in the mid-1970s in Kenya. It comprises dynamic, process-oriented techniques to identify and respond to local concerns and is widely used in grass-roots community works in East Africa (Cornwall *et al.*, 1994). 'Listening surveys', conducted by the facilitator and followed by preparation 'codes' such as pictures and songs, are important activities used to reflect local problems. An action plan is then prepared to address the problem after discussing and analysing each 'code' in an open meeting. The DELTA approach focuses on facilitating local-level reflection and action from marginalised groups and the research and extension activity reflects local people's experiences. However, the effectiveness of this approach is very much influenced by the facilitator's skills and intentions.

The *Theatre for Development* approach is based on using performance arts, such as theatre, songs, dance and puppetry, mainly for extension purposes. This approach also can be used to create solutions to the problem by inviting people to intervene in dramatised scenarios of their everyday lives (Cornwall *et al.*, 1994). This approach also uses 'Listening surveys' and 'codes' as in the DELTA approach. However, the process of action and reflection in this approach is guided by creative conflict, in contrast to consensus in the DELTA approach.

Agroecological approaches were agricultural innovations developed as alternatives to capital and chemical-intensive mainstream strategies for farm productions. Mainstream production strategies rely more on fossil fuels and chemicals, which are contributing to environmental degradation. Such strategies contributed to world food production in the past mainly in the areas ideal for crop production; however their effectiveness in favourable areas has not maintained its momentum, as the rate of yield increase is decreasing, and they have remained generally ineffective in less favourable areas (Fernandes *et al.*, 2002; Uphoff, 2002). Thus the general benefits of increased world food production were not realised by the vast majority of farmers in the less favourable environments of Asia, Africa and Latin America.

To address these issues, agroecological approaches, ecosystem-based production systems, were developed. Agroecological approaches consider ecological concepts and principles in the design and management of sustainable agroecosystems (Altieri, 2002). This approach optimises the use of locally available resources and reduces dependency on off-farm/ external, non-renewable inputs, so the technologies are known as low-external-input technologies. This is an eco-friendly option for meeting the growing demand for food (Uphoff, 2002). This approach gives greater emphasis to production systems than to individual technologies, so it does not favour monoculture production approach. Rather it aims to increase total productivity of the system through diversification of farming by integrating crops, trees, livestock and aquaculture in the production system. Agroecological approaches are used not only for increasing production but also to improve the quality of production systems. Greater roles for farmers in experimentation and evaluation increase their competence and confidence achieving greater human resources development (Uphoff, 2002). This emphasises processes not just products, as methodologies for agricultural innovation are considered as important as technologies. Agroecological approaches stress diffusion rather than transfer of technology. Technology developed in a favourable area is less likely to be successful if transferred directly to marginal, less favourable areas. Such technologies need to be modified for them to be suitable for the diverse and complex production environments of marginal areas. The design of such agroecological approaches applies the following ecological principles (Reijntjes *et al.*, 1992 as cited by Altieri, 2002).

- *'Enhance the recycling of biomass, with a view to optimising nutrient availability and balancing nutrient flow over time.'*
- *'Provide the most favourable soil conditions for plant growth, particularly by managing organic matter and by enhancing soil biotic activity.'*
- *'Minimise losses of energy and other growth factors within the plants' micro-environments above and below ground. These losses result from unfavourable flows of solar radiation, air and water. Reduction is accomplished through microclimate management, water harvesting, and better soil management and protection through increased soil cover.'*
- *'Diversify species and genetic resources in the agroecosystem over time and space.'*
- *'Enhance beneficial biological interactions and synergies among the components of agrobiodiversity, thereby promoting key ecological processes and services.'*

Evidence from a number of development programmes and from diverse conditions indicates that low-external-input technologies can be efficient and sustainable (Tiffen and Bunch, 2002). However, the potential of such alternative agroecological approaches will only be fully understood when these are considered more widely and evaluated more systematically (Fernandes *et al.*, 2002).

In summary, innovation systems are continuously evolving. 'Blueprint' or 'Package of Practice' approaches did not work well, particularly in areas with diverse geo-climatic and socio-economic situations. This necessitated the decentralisation of research and development activities according to their geo-climatic and socio-economic contexts, which led to the evolution of on-farm and participatory innovation systems. Participatory approaches aimed to secure better roles for local communities in research and development activities to produce more meaningful outcomes. The philosophy of participatory research and development was founded to allow target communities to identify their own needs and develop or select innovations appropriate to their own bio-physical and socio-economic situations. The process is designed to improve their understanding of available resources and constraints; to handover control over resources and decisions to them; to encourage them to develop their capacity to undertake research and to empower them. Participatory approaches emphasise bringing oppressed and marginalised people to the forefront of the research and development process and engaging in wider debates about social justice and community development (Okali *et al.*, 1994). The level of farmer participation in the process, and their access to and control over resources and decision-making is, however, not the same in different innovation systems.

The SHASEA project, to be considered in a later chapter, adopted an holistic and multidisciplinary approach to implement project activities. The basic research was conducted in a research station and the applied research was implemented under farmers' field condition (SHASEA, 2003). Thus, the innovation system of the SHASEA Project was similar to the FSR/E approach and *Model I* of the FPR approach (Cornwall *et al.*, 1994).

2.1.3.2 Sustainable agriculture projects in S.E. Asia

There is a clear distinction between sustainable agricultural initiatives on flat and sloping land. Land with a ≥35% gradient is categorised as sloping land, which is vulnerable to rapid loss of topsoil in response to agricultural practices (Sombatpanit, 2001). Steep gradients favour rapid overland flow, which increases soil loss and decreases soil moisture retention. Thus, sloping lands generally have shallow soils, low organic matter content and poor moisture retention. Topsoil loss often decreases productivity and usually decreases nutrient supply (Sajjapongse, 1992). So, initiatives for flat land have been focussed on improving fertility status and soil biological properties, while on sloping land efforts have been focussed on reducing soil, water and nutrient losses, by reducing runoff and thereby erosion.

Consequently land degradation and desertification have decreased along with the improvement in fertility status and soil biological properties (Nutalaya, 1991; Pratap and Watson, 1994; Tang Ya, 1999; Fullen *et al.*, 2001; Panomataranchagul *et al.*, 2001). However, these spatial dynamics of soil/water erosion and land degradation need to be borne in mind when assessing the sustainability of agricultural projects. Similarly, temporal dynamics and the interaction between spatial and temporal dynamics need to be considered during the evaluation.

Considerable efforts have been made, from both research and development perspectives, in the sustainable management of sloping land in Asia (Sajjapongse, 1992; Pratap and Watson, 1994; Maglinao *et al.*, 1995; van Keer *et al.*, 1998; Tang Ya, 1999). The majority of the sustainable development programmes/projects in the sloping uplands of S.E. Asia had one or more of the following objectives: conserving natural resources, reducing soil and water erosion, improving/maintaining soil fertility, improving crop production and food security and achieving rural development (Annex 2.1). Such programmes/projects were implemented under one or more of the following thematic programme areas:

- Highland development programmes.
- Sloping land and natural resources management programmes.
- Food security, poverty alleviation and rural development programmes.
- Cropping systems programmes/ farming system programmes.

2.1.3.2.1 Highland development programmes

Considerable efforts have been made to improve the natural resources of the tropical highlands of Asia, particularly Thailand and Vietnam. Highlands are arbitrarily defined as the ecozone above an altitude of 500 m (van Keer *et al.*, 1998). Agriculture in highland areas is characterised by subsistence and shifting cultivation practices, which involve large scale clearing of the natural vegetation and subsequent cultivation on steep to very steep slopes (van Keer *et al.*, 1998). Soil and water erosion is one of the main problems in the highland areas of S.E. Asia. In addition, widespread opium production and consumption by rural tribes in highland areas had posed not only health risks, but were also a threat to regional security. Often agriculture development and natural resources management programme were linked with narcotics control programmes, thereby resulting in collaboration between unusual and unrelated disciplines, such as agricultural development and narcotics control.

2.1.3.2.2 Sloping land and natural resources management programmes

Two international institutions, viz. the ‘International Centre for Integrated Mountain Development’ (ICIMOD) and the ‘International Board for Soil Research and Management’ (IBSRAM), have given high priority to achieving greater sustainability on sloping lands. ICIMOD started to test and demonstrate sloping agricultural land technology (SALT) with particular emphasis on contour hedgerow technology from 1991 (Pratap and Watson, 1994; ICIMOD, 1999; Tang Ya, 1999). This system is being increasingly studied and tested in many countries. IBSRAM developed Sustainable Land Management (SLM) technologies with particular emphasis on different crop combinations for alley cropping systems and on developing a framework for evaluating SLM projects (Dumanski *et al.*, 1991b; Sajjapongse, 1992; Maglinao *et al.*, 1995; Sajjapongse and Elliott, 1995; Sajjapongse and Leslei, 1998). The soil conservation and sustainable agriculture programme in the Loess Plateau of China gave greater emphasis to restoring vegetation cover in order to increase rain water infiltration and decrease soil-water movement in the vast bare area of the plateau (Liu Guobin, 1999).

2.1.3.2.3 Food security, poverty alleviation and rural development programmes

Addressing food security and poverty is almost compulsory to achieve rural development goals in the area. Moreover, the over-exploitation of natural resources leading to land degradation is often blamed for the poverty of the local residents. This can be recognised by the fact that rural development and natural resources management programmes have placed considerable emphasis on addressing rural poverty by increasing on-farm and/or off-farm income generating enterprises to improve the livelihood of rural poor (Do Thi Ngoc Oanh *et al.*, 1997; ADB, 1999; Liu Guobin, 1999; Monschein, 1999; Evans and Sophana, 2004). The international crop research programmes of CGIAR are focusing their activities on generating technologies for improving crop productivity to achieve food security and, thereby, the sustainability of agricultural systems (Wills *et al.*, 1987; Gerpacio, 2001; ICRISAT, 2002; IRRI, 2003; CIMMYT, 2004).

2.1.3.2.4 Cropping systems programmes/ farming systems programmes

Most projects within this theme were implemented in poverty-stricken areas, where subsistence farming systems were predominant. Most were implemented using cropping systems or farming systems approaches to meet the need of subsistence farming communities. Some projects, however, have been specifically dedicated to improving farming systems using a wide range of technologies, for example: ‘Evaluation and Improvement of Farming Systems in the Mekong Delta’ (Kokubun, 1998), ‘Asian Grain Legumes On-farm Research Project’ (Gowda *et al.*, 1996), ‘Cambodia-IRRI-Australia

Project' (Nesbitt, 1997), 'Improvement of the Sustainability of Cassava Based Cropping Systems in Asia' (Howeler, 1996).

Many projects/programmes used participatory approaches during one or another phase of the project (Howeler, 1996; Cruz, 1997; Do Thi Ngoc Oanh *et al.*, 1997; Renaud and Attaviroj, 1997; Bhatia and Karki, 1999; Monschein, 1999; Acton and Thai Phien, 2001; Ritsema *et al.*, 2001; Cai Mantang, 2003; Evans and Sophana, 2004; SFDP, 2004) (Annex 2.1). The extent of consolidated participation also differed, as some projects involved people in certain activities only, while others involved participation throughout the project cycle. A more detailed analysis of this aspect, however, has not been possible due to limited information availability, particularly about project processes.

2.2 Review of specific programmes/projects in S.E. Asia

In the following section, a number of programmes, which were implemented in S.E Asia, have been reviewed to illustrate the range of work that has been carried out in the region. Their role in developing and promoting sustainable agricultural technologies has been summarised in the following sections.

2.2.1 International/regional programmes

Some large-scale international and regional programmes were established in S.E. Asia. Brief descriptions of some of these programmes have been presented below:

The International Centre for Integrated Mountain Development (ICIMOD) was established in 1983 to promote progressive and effective development of mountain communities in the Hindu Kush Himalayas (HKH) (ICIMOD, 2004). The primary objectives of the Centre are to help promote the development of an economically and environmentally sound mountain ecosystem and to improve the living standards of mountain populations, especially in the HKH Region. Some of the key research activities of ICIMOD are mountain resource management, rehabilitation of degraded lands, and sloping agricultural land technology (SALT) (Annex 2.2).

The International Board for Soil Research and Management (IBSRAM) was established in 1985, based in Thailand. The aim of IBSRAM was to help National Agricultural Research Systems (NARS) in developing appropriate and sustainable land management practices for food and other agricultural produce. IBSRAM promoted and conducted collaborative research on all aspects of land management, with a mission to contribute to poverty alleviation and food security in developing regions through research and related activities that promote sustainable land management and a healthy environment (CIFOR, 1999). IBSRAM contributed to upgrading research facilities and training workers in partner countries and institutions; developed modern methodologies and diagnostic tools; established relevant concepts and models; established multi-agency linkages and collaboration; developed appropriate technologies and practices of sustainable land management (SLM) and produced quality publications and other information material. ASIALAND was one of the biggest and longest running projects of IBSRAM.

Mekong development programme the Mekong Commission was established by Cambodia, Lao PDR, Thailand and Vietnam for the sustainable development of the Mekong river basin (Mekong River Commission, 2004). Later need for systematic and sustainable development in the Mekong region, with a harmonised approach to development, was realised by the international aid community. So the Greater Mekong Subregion (GMS) was created comprising Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam, and Yunnan Province in the People's Republic of China (ADB, 1999).

The Regional Community Forestry Training Center (RECOFTC) was established in 1987 in Thailand and has been working for the Asia Pacific region to promote, develop and provide training in community forestry. The programme of RECOFTC comprises three interlinked elements: collaborative country support, inter-country sharing or "common topics" and regional services (RECOFTC, 2003; Forestcommunities.org, 2004).

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is one of the 16 Future Harvest Centres of the Consultative Group on International Agricultural Research (CGIAR). The mission of ICRISAT is to help developing countries apply science to increase crop productivity and food security, reduce poverty and protect the environment. ICRISAT focuses on the farming systems of semi-arid tropical areas of the developing world, where erratic rainfall, low soil fertility and extreme poverty are formidable constraints to agricultural development (ICRISAT, 2004).

The International Water Management Institute (IWMI) is one of the Future Harvest centres of CGIAR established in Sri Lanka. IWMI is focusing on the sustainable use of water and land resources in agriculture and on the water needs of developing countries. IWMI works with partners in the South to develop tools and methods to help these countries eradicate poverty, through more effective management of their water and land resources (IWMI, 2002).

Among the programmes/projects, the International Centre for Integrated Mountain Development (ICIMOD), International Board for Soil Research and Management (IBSRAM) and Greater Mekong Sub-Region (GMS) Programme, were among the large-scale initiatives, with considerable emphasis on sustainable agriculture and land management systems in S.E. Asia. These programmes were implemented at a regional scale with longer-term commitments involving multiple funding agencies.

2.2.2 Bilateral projects

In addition to the large-scale regional programmes, large numbers of bilateral projects between donor countries/funding organisations and implementing host countries have been carried out in S.E. Asia with the financial assistance of developed countries and the international funding community. Brief descriptions of such projects are presented below as examples.

2.2.2.1 Thai-German Highland Development Programme (TG-HDP)

TG-HDP was implemented in highland areas of Chiang Rai and Mae Hong Son Provinces of Thailand during 1981-1998. The objective of the programme was to improve the standard of living of the highland population, reduce drug problems and maintain an ecological balance (TG-HDP, 1999). Major activities of the programme included: sustainable farming systems (improved subsistence and cash farming practices), conservation of natural resources (particularly forest, soil and water), and development of land use plans. In addition to these, the programme carried out a broad range of activities, such as consolidation of physical infrastructure and improved access to markets; training for women in production techniques, management and marketing to enhance their income generating capacities and expansion of education and health services for the integration of the highland population into the mainstream of the Thai nation. This programme adopted a different approach to the problem of controlling drugs by aiming for agricultural sustainability of highland farming systems. This led to collaboration with the Narcotics Crop Control Division (NCCD). The programme was successful in: reducing opium production (9000 ha in 1988 to <1000 ha in 1990); improving living standards; improving access to agricultural extension services, education and health facilities as well as to new markets and sources of income; improving road networks and thereby expanding the highland's agribusiness and tourism (TG-HDP, 1999; Dirksen, 2001; Dirksen, 2002).

2.2.2.2 Thai-Australian Highland Agricultural and Social Development (TA-HASD) Project

HASD was a large, long running (1982-1993) integrated area development project implemented in six provinces of Northern Thailand with the objectives of improving the lives of hill tribe peoples in Northern Thailand and reducing environmental degradation. The project was an extension of the Highland Agricultural and Social Development (HASD) project. The goal of the project was 'to generate sustainable improvements in the environmental, social and economic welfare of the Highland people in Northern Thailand'. The purposes of the project were to:

- introduce sustainable farming systems to the project area;
- increase crop production for consumption and sale;
- improve the social conditions of the target group, in particular, to increase the opportunities for them to participate in development programmes and in Thai society;
- strengthen the capacity of the Hill Tribe Welfare Division of the Department of Public Welfare to carry out its operations;
- encourage line agencies to further carry out their roles in the development of the highland peoples and to assist in the coordination of these activities (AusAID, 1999b).

Project activities were carried out under three programmes, i.e. agricultural development, community development and institutional support. These included food and cash crop production, farming systems, livestock health, extension services, watershed protection, land use planning, health and education services, access to citizenship, road access, village water supplies and regional information systems. According to the project completion report (PCR), the project achieved and, in some cases, exceeded output targets. Indeed, estimates at the completion of the project indicated an economic internal rate of return of about 35%. The few areas of under-achievement were primarily associated with difficulties in securing relevant cooperation and/or support from other line agencies, especially in the areas of education and the provision of road access (AusAID, 1999b).

2.2.2.3 Sustainable development initiatives in highland areas of China

In China 38.2% of the total area is subject to soil erosion, of which 179 million ha are subject to water erosion. The annual soil loss is estimated to be 5000 million tonnes, together with a large amount of nutrients. About 70% of the soil erosion in China occurs from agriculture related activities (Tang Ya, 1999). Deforestation over hundreds of years has forced people to use greater amounts of agricultural residues for fuel, with consequent reduction in soil fertility and increases in soil erodibility (SUAS, 1990).

The ‘Chinese-Swedish Soil Conservation Project’ was implemented in the Loess Plateau of China with the overall objective of reducing soil erosion in the region (SUAS, 1990; SUAS, 1991). The project focussed its activities on soil improvement through chemical and biological methods. These included diversifying land use systems through the adoption of fruit trees and forages or annual crops, inter-cropping and soil conservation through the use of multipurpose forest species on slopes.

2.2.2.4 Sino-German Food Security Programme, Shandong

This was a longer duration (10 years) project implemented in Shandong Province, China during 1988-1998. Rural development activities (drinking water project) were implemented in association with activities aimed at increasing production, for example cash crops, vegetables, irrigation, sloping land management and forest management activities (Monschein, 1999).

2.2.2.5 The Cambodia-IRRI-Australia Project

This was a collaboration project between the Cambodian Government, the International Rice Research Institute (IRRI) and the Australian Agency for International Development (AusAID). Cambodia was one of the major rice exporters; however, years of warfare and genocide in the country led to a serious decline in production. As a result the rice crop was insufficient for domestic consumption. This long-term project (1988-2001) was implemented to establish technologies to develop sustainable rice-based farming systems and increase rice production (Nesbitt, 1997; AusAID, 1999a).

2.2.2.6 Food Security in Arid Uplands

This IDRC (International Development Research Centre, Canada) supported project was implemented in critically under-developed areas of Indonesia, with the objective of enabling local families and communities to improve their food security and family welfare (IDRC, 2003).

2.2.2.7 Farming Systems Project in the Mekong Delta

This project was implemented in Vietnam with support from the Japan International Research Center for Agricultural Research (JIRCAS) to evaluate and improve farming systems (agriculture, animal husbandry and fisheries) in the Mekong Delta. The objective of the project was to improve existing traditional farming practices. The research activities were focused on developing new technologies of rice production, better practices for livestock management and aquaculture nursery management for prawn production (Kokubun, 1998).

2.2.3 Review of effectiveness of projects implemented in S.E. Asia

The previous sections illustrate the range of projects undertaken in S.E. Asia, but give little insight into how effective these have been in achieving long-term benefit. This review of the agricultural development projects implemented in this region has been undertaken not only to study their effectiveness but also to identify the successful aspects of the projects in different socio-political, environmental and biological contexts. This has included an attempt to identify 'effective' or 'successful' sustainable agricultural technologies and project implementation processes for different socio-political and environmental situations, particularly in China, Vietnam and Thailand.

Preliminary information (name, address and main features) about the projects was collected from web sites, journals, proceedings, and brochures. Various organisation and resource personnel were contacted for the list of relevant projects. Some longer duration projects (Mekong Development Project, The Highland Peoples' Programme, Social Forestry Development Project) and some funding agencies (GTZ, EU, IDRC, Finland and JIRCAS) were investing considerable efforts in the sustainable development of the region. So those institutions were also contacted for information. Information on 68 projects was collected and compiled. Projects aimed at addressing sustainable agriculture, soil erosion, poverty and food security, implemented with participatory approaches and multidisciplinary programmes, and implemented during the last decade on sloping land/upland in South-East Asia, were considered relevant for a more detailed study of outcomes and effectiveness.

2.2.3.1 Problems encountered in attempting a more detailed analysis

More than 100 organisations and resource personnel were contacted for project-related information/reports to carry out further review work. The organisations were requested to provide detailed information about project processes (management, implementation, and evaluation) and products (technical outcome, adoption). However, little success was achieved, as detailed information for only two projects and some information on seven other projects was received. Project completion reports (PCR) were requested from organisations involved in research/development programmes in order to study project products, processes and consequent adoption/adaptation of project interventions by targeted stakeholders. This would have provided an opportunity to identify and outline both positive and negative practices of sustainable agricultural research and development interventions in the past and draw suggestions for the future. However, this effort was impaired severely as none of the organisations requested provided this documentation. Though there is a tendency for sharing technical outcomes widely, both funding and implementing agencies were unwilling to reveal project processes, which they treated as confidential. Thus experiences about past interventions remain isolated within the funding and implementing agencies, which has inhibited the build-up and refinement of a common knowledge base in this area. This itself is a revealing outcome and could be one of the reasons for slow progress in achieving significant improvements in sustainability. Some organisations suggested exploring their web site. Information about on-going projects was often well presented on web sites, but relevant and detailed information about completed projects was normally absent. All these factors made it very difficult to carry out a comprehensive evaluation of the full effectiveness of past projects, except for the technical/scientific outcomes which are normally published in refereed journals. These rarely, if ever, refer to the extent to which effective technologies have been adopted by the local communities after the end of the funded programme.

2.2.3.2 Results of the review of 68 projects

Some analyses were performed using available information on the 68 projects, which firstly showed that a total of 37 funding/coordinating organisations were involved in supporting these sustainable agricultural research and development interventions in S.E. Asia. The International Development Research Centre (IDRC), European Community (EC), the Australian Government's Overseas Aid Programme (AusAID) and International Centre for Integrated Mountain Development (ICIMOD) were among the most heavily involved funding/coordinating organisations (Table 2.1). The average duration of the projects studied was 6.8 years, which ranged from 2.25-30 years. However, the duration of 71% projects studied was between 3 -7 years. The projects were started during 1970-1999, however most of them started during 1987-1999. There was a declining trend in project duration over time.

2.2.3.3 Results from a larger sample of projects

An additional desk survey was done to study the change in project duration over time. The information was sampled from the *Development Gateway* (Development Gateway, 2003) during 2003. This compiled brief information on projects covering sustainable agricultural development or related issues (such as food security, poverty alleviation, rural development, natural resource management, soil-water conservation) which were relevant to this study. Information on 719 projects, which started during 1970-1999, was considered for further analysis (Table 2.2).

Considering the number of funded projects, the Department for International Development of the United Kingdom (DfID), the Netherlands, The Australian Government's Overseas Development Aid Programme (AusAID), Norway, World Bank, Denmark, Canadian

International Development Agency (CIDA), International Development Research Centre (IDRC) were among the most heavily involved funding agencies in the development of S.E. Asia.

Table 2.1 Organisations involved in funding/co-ordinating the 68 agricultural research and development projects in South Asia included in the review.

SNo	Funding/co-ordinating agency	Number of projects
1	ADB – Asian Development Bank	3
2	AIC – Agricultural Institute of Canada	1
3	AusAID - The Australian Government's Overseas Aid Programme	8
4	Belgium Government	1
5	Catholic University, Leuven, Belgium	1
6	China (self-funding)	1
7	CIAT – International Center for Tropical Agriculture	2
8	CIDA – Canadian International Development Agency	2
9	CIFOR – Center for International Forestry Research	1
10	CIMMYT – International Maize and Wheat Improvement Center	1
11	EC – European Community	8
12	EU – European Union	4
13	FAO – Food and Agriculture organisation	1
14	Finland Government	3
15	GTZ - Deutsche Gesellschaft für Technische Zusammenarbeit GmbH	3
16	Helvetas (a Swiss NGO)	1
17	IBSRAM (ASIALAND) – International Board for Soil Research and Management	2
18	ICIMOD – International Centre for Integrated Mountain Development	6
19	ICRAF – International Center for Research in Agroforestry	1
20	ICRISAT – International Crops Research Institute for Semi-Arid Tropics	1
21	IDRC – International Development Research Centre	10
22	IFAD – International Fund for Agricultural Development	1
23	IIED – International Institute for Environment and Development	1
24	IRRI – International Rice Research Institute	2
25	IUCN – World Conservation Union	1
26	JIRCAS – Japan International Research Center for Agricultural Sciences, Japan	1
27	Munich Research Alliance on Agro-ecosystems (FAM)	1
28	Nippon (Sasakawa) Foundation, Japan	1
29	RECOFTC – Regional Community Forestry Training Center for Asia and the Pacific	1
30	SC-DLO - DLO Winand Staring Centre for Integrated Land, Soil and Water Research, Netherlands	1
31	SDC – Swiss Agency for Development and Cooperation	3
32	SNV - Schweizerischen Normen Vereinigung (Netherlands Development Organisation)	2
33	Swedish University of Agricultural Sciences	2
34	UNEP- United Nations Environment Programme	1
35	University of British Columbia, Canada	1
36	University of East Anglia, UK	1
37	University of Wolverhampton, UK	2

Table 2.2 Organisations involved in funding the agricultural research and development projects in S.E. Asia included in the larger sample of projects.

SNo	Funding organisation	Number of projects
1	ADB	3
2	AusAID	36
3	CU Belgium	1
4	China	1
5	CIDA	13
6	CIMMYT	1
7	EC	8
8	EU	4
9	FAO	1
10	Finland	3
11	GTZ	3
12	Helvetas	1
13	IBSRAM	1
14	ICIMOD	1
15	ICRAF	1
16	ICRISAT	1
17	IDRC	10
18	IIED	1
19	IRRI	1
20	JIRCAS	1
21	FAM Alliance	1
22	Nippon	1
23	RECOFTC	1
24	SDC	1
25	SNV	2
26	SUAS Sweden	2
27	UNEP	1
28	UEA UK	1
29	DfID	261
30	BMAA, Austria	4
31	DANI, Denmark	14
32	DGIS, the Netherlands	39
33	NORAGRIC, Norway	34
34	World Bank	25
35	KFWI, Germany	5
36	SADC, Switzerland	5
37	SIDA, Sweden	5
38	FIMF, Finland	2
39	MacArthur Foundation	4
40	NOMF, Norway	2
41	DANC, Denmark	1
42	UCAP	4
43	Others	212
	Total	**719**

2.2.3.4 Change in the funding policies of donor organisations

A statistical analysis of the 719 projects implemented in S.E. Asia was performed. Project duration ranged from 1-30 years with an average duration of 4.8 years (median = 4 years and mode = 2 years). Moreover, the duration of 584 (81%) projects was ≤ 6 years (Fig. 2.1).

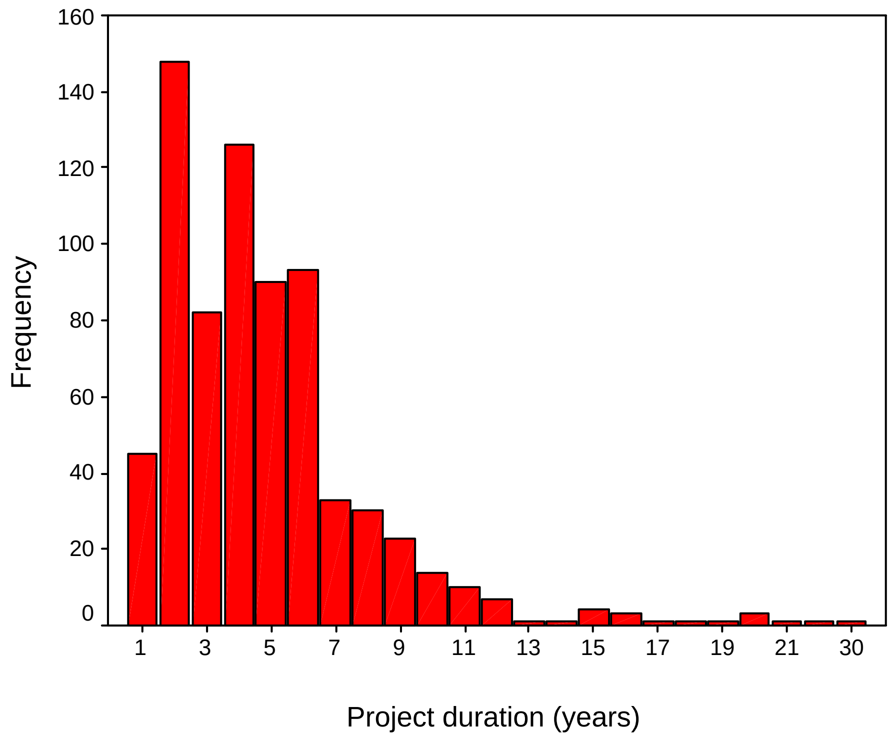

Figure 2.1 Duration of sustainable development projects implemented in S.E. Asia during 1970-1999.

It is interesting to note that there was a decreasing trend in the duration of projects over time. The duration of the later implemented projects was shorter compared to earlier implemented projects ($r = -0.588$, $P<0.001$, $N = 719$; Fig. 2.2). This reveals that funding agencies have inclined towards funding shorter-duration projects. This is not an encouraging development, as short duration projects often fail to achieve or demonstrate effective and sustainable change. A number of authorities have recognised that at least 5 years are required to produce tangible outputs from conservation projects (SUAS, 1990). Considering the tendency of agricultural systems to change slowly, Hudson (1991) suggested planning a 10-year horizon for such projects, as a norm.

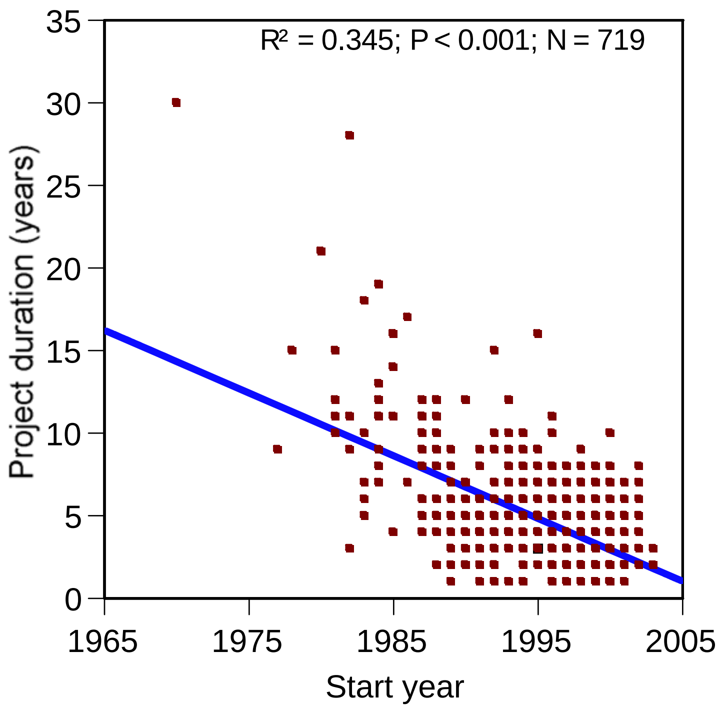

Figure 2.2 Changes in the duration of projects started during 1970-1999.

Official development assistance to agriculture in developing countries decreased from US$ 13-14,000 million/year during 1982-86 to US$ 9300 million in 1996 (Trotter and Gordon, 2000). Similarly agricultural assistance per capita of population in the least developed countries fell by almost 50% between 1982 and 1995. In addition, the trend in agriculture's share of total funding fluctuated and declined from 33% to 19% between 1980 and 1996 (Trotter and Gordon, 2000). In a similar fashion, Pinstrup-Anderson and Pandya-Lorch (1998) reported a declining trend in total official assistance to both overall development and agricultural development. Such a declining trend in international assistance to agricultural development in developing countries could be one of the reasons for the reduction in project duration over time. Moreover, such a trend forces developing countries to accomplish their goals with less assistance.

2.3 Identification of issues related to successes and failures of agriculture projects

This section refers primarily to other published reviews because of the lack of critical information available from the above survey. Hudson (1991) evaluated 40 projects implemented in Africa in an attempt to study the reasons for success or failure of soil conservation projects. A comprehensive list of factors responsible for success/failure of the projects has been collated into three main groups, summarised below:

- *Before project implementation:* Poor design was one of the main reasons for the failure of a project. The World Bank evaluated about 1000 projects, of which 86% had inappropriate project design; poor performance in one-third of these cases was primarily because of the poor design. Incorrect assumptions were the main reason leading to poor project design. Funding agencies and host countries were both responsible for the poor design of projects. Over-optimism, over-estimation of rate of adoption and ability of the host country, under-estimation of time required to mobilise human and material resources and unrealistic estimation of the economic benefits were some of the reasons.

- *During project implementation:* The majority of projects experienced problems due to delay in staff (both international experts and local counterparts) appointments. Delegation of responsibility was identified as an important aspect in project design, which enabled field managers to respond quickly to the action required. Similarly, introduction of the new technologies/methodologies without testing appropriately in the target environment was identified to be a primary reason for reported failures. Inadequate project monitoring was also identified as a common weakness.

- *After project implementation:* Project evaluation was considered to be important, which would help in spreading good practices and identifying errors which should not be repeated. There was increasing realisation of the need for evaluation, but (Hudson, 1991) found that the evaluation was not done with sufficient rigour; as a result many projects could not identify who benefited and by how much. Techniques of project evaluation have been continuously improved during the last past decade. Similarly, new indicators and jargons associated with project evaluation have also been coined (Faures, 1997; Wattenbach and Friedrich, 1997; Gorrie, 1999; UN, 1999; CSD, 2001; Walmsley, 2002). The evaluation of a project is done in the light of these indicators and criteria that were not available when the project was planned. Therefore projects will always be vulnerable to criticism in evaluation reports.

Edwards and Farrington (1993) reviewed 21 renewable natural resources projects and on the basis of uptake of project output by different users, they judged that 11 projects were successful, five failed and the remaining five had elements of both success and failure (Garforth and Usher, 1997). Irrelevance or inappropriateness of the research outputs was one of the major reasons for low uptake of the project outputs.

The working approaches of external (funding) and internal (implementing) agencies' have been found to have a significant role in the subsequent adoption and impact of sustainable development interventions. Tang Ya (1999) evaluated Sloping Land Agriculture Technology (SALT) to study the factors influencing the adoption of soil conservation technology by farmers. The SALT project was implemented in six countries of Hindu Kush Himalayan (HKH) region by ICIMOD. He found farmers' adoption of SALT to be lower than expected in four out of six countries, despite the fact that SALT had numerous comparative advantages over the existing terracing technology. The study revealed that successful adoption of the recommended technology occurs only when aid agencies, implementation agencies, and farmers work together and have close collaboration. Inadequate demonstration of the technology in terms of its advantages and disadvantages, lack of direct and visible benefits and lack of farmers' awareness of the environmental problems contributed to low adoption. A contributing factor was the inadequate availability, continuity and commitment of project staff, which in turn resulted in inadequate communication between farmers and project staff.

Tang Ya (1999) recommended the following for the wider adoption of effective technologies for soil water conservation:

- Technologies should be able to address effectively soil and water erosion problems and be applied without many limitations.
- Before it is accepted and adopted by farmers, a technology should be adequately demonstrated and not only the potential benefits identified but also the possible limitations.
- Necessary mechanisms need to be developed to encourage project staff to commit to the work.
- Various media which farmers feel familiar with should be used to increase awareness of soil erosion and other environmental degradation problems.
- Government policy is needed to promote the adoption of the technology by farmers.
- Incentives should be provided based on what has been achieved, not on what was planned.

Ruaysoongnern (1999) studied a soil conservation project implemented in N.E. Thailand. He considered the size of budget available to be the important contributing factor for the adoption of soil conservation technologies. He presented a list of factors contributing to the success and failure of the project:

- Clear identification of problems and potentials.

- Adequate and continuous funding, with promotion support from provincial offices.
- Short distance and easy travel from the office to the project site.
- Strong farmers' group.
- Obvious, but not too severe, land degradation problems in the project area.
- Proven effectiveness of potential technology supported by local experience and visits to successful demonstration sites.
- Available family labour to implement conservation practices.
- Available family resources, e.g. tools, capital inputs.
- Good supply of water.
- Access to suitable markets for products from the improved agricultural production.
- Continuous project support through knowledge and external inputs (which are not available locally), including management skills.

Fujisaka (1991) studied six different upland agricultural research and/or development projects implemented in the Philippines, Indonesia and Laos. He examined the technologies offered to farmers and farmers' adoption of these technologies, in order to understand the underlying reasons for both adoption and non-adoption. He identified the following reasons for non-adoption of soil conservation technologies:

- Absence of a problem.
- Inappropriate innovation.
- General unawareness about the problem.
- Incorrect identification of the adoption domain.
- Appropriateness of the farmers' practices.
- Adverse off-site effects.
- Generation of new problems from innovation.
- Costly innovation.
- Insufficient extension services and inappropriate information.
- Insecure land tenure.
- Farmers may be "mining resources" due to competition between groups for resource use.
- Negative social connotations (socially unacceptable technology).

In addition, he identified two main factors that favoured adoption.

- Adoption as a response to other incentives attached to the project technology.
- Potential for widespread adoption.

The project evaluation mission of CSSCC Project concluded the project was successful; however it raised the following issues about the project (SUAS, 1990; SUAS, 1991).

- The project duration (3 years) was insufficient to yield any tangible output from such activities (agro-forestry, soil fertility), which are long term in nature. It suggested at least 5 years of project period for a conservation project like this.
- Poor research-extension linkage in the project. There was lack of institutional capacity to undertake farming system research, which was not planned in the original project design.
- The experiments on steepest slopes, less fertile and marginal land were inconclusive, meaning that farmers in these areas were not able to enjoy the benefit of research activities.
- Extension was not originally part of the project.
- The weakest overall element in project design and implementation was in the evaluation of results and failure to define criteria to evaluate complex experiments.

The project also outlined some issues for future considerations.

- Present studies should be complemented by on-farm trials.
- Socio-economic analysis of farming households should be an essential component of any future programme. The applicability of the technical research must be assessed in terms of local constraints.

In addition to the points raised by the evaluation mission, the following issues may constrain the level of adoption/adaptation of the technology by farmers.

- The project failed to recognise the farmers as important stakeholders and their role in project processes. The lack of farmer participation led to doubt about the usefulness of the technologies generated to the farmers and their subsequent adoption/adaptation by farmers as expected by the researchers. This is evident from the fact that benefits from project technologies were not realised in marginal areas.
- Project activities conducted within the Research Institute were more of a scientific nature.
- No plan was indicated for dissemination of the research results.

2.4 Concluding summary

In concluding this review, the following issues can be highlighted.

- The World's growing population is placing an increasing demand for food. In attempting to satisfy this demand, activities have been focussed on increasing production, without due attention to the resultant effects (both short- and long-term) on natural resources. As a result, large parts of the world are now facing the problems of soil degradation, water erosion, groundwater pollution and natural resources depletion leading to decreased crop production in these areas, due to which the sustainability of current agricultural systems is in question.

- Sustainability itself is a broad issue and comprises several different disciplines. As a result sustainability has been defined in several different ways. The definition presented by FAO is most relevant to this study: *"Sustainable agriculture should involve the successful management of resources to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources"*. Different factors have been reported to affect agricultural sustainability, which include technical, environmental, economic, working approach, farmers (grass root), social, institutional, scale and duration of operation, temporal dimension of the impact, political and policy related factors.

- Indicators of sustainability have been identified and different frameworks have been developed as tools for planning, monitoring and evaluating agricultural sustainability. In addition to this, investigations have been carried out to study the successes and failures of past projects in order to improve future projects.

- Similarly, considerable emphasis has been placed on developing technologies for agricultural sustainability, including contour cultivation, reduced/minimum/no-tillage, mulching, crop rotation, intercropping, alley cropping, agro-forestry and use of organic matter.

- Sustainability of agricultural systems in marginal areas, particularly sloping uplands, has gained more attention from national governments and international aid agencies in recent years. The serious threat to the ecosystem and livelihood of the farmers of those areas as a result of land degradation (soil and water loss, erosion and desertification) is a major concern and intensification of agricultural practices is considered to be one of the main factors responsible for land degradation. Despite its advantages, intensive agriculture has many disadvantages. Rapid mining of inherent soil fertility, deterioration of soil qualities and acceleration of soil and water erosion are the common disadvantages of intensive agricultural systems, which are particularly pronounced in sloping uplands.

- Large numbers of bilateral programmes/projects are working on the sustainability of agricultural systems; however they vary greatly in scale of operation (project area, duration and fund), focus area and working approach.

- Analysis of the duration of agricultural development projects implemented in S.E. Asia revealed that funding agencies are tending to fund shorter-duration projects. The duration of 81% (584) projects was ≤ 6 years. Short duration projects are not as effective as long term projects and programmes, as it is difficult to produce tangible outputs from conservation projects within five years.

- Longer duration projects, such as the TG-HDP and TA-HASD Projects, were successful in addressing more holistic issues than short duration projects like the CSSCC Project.

- It was very difficult to get programme completion reports (PCR) or details of project processes from project teams and funding agencies. There is a general lack of critical information on the effectiveness of agricultural development projects in the public domain.

- Most projects that have been evaluated have identified weaknesses that are likely to limit future and widespread adoption of the introduced technologies. These will be considered further in Chapter 9.

Chapter 3: Socio-economic background of Kelang Village

This chapter gives an overview of the socio-economic conditions in Kelang village in 2002 and 2003. The SHASEA Project was based on the Wang Jia catchment, adjacent to the village of Kelang, from 1998. Information in this chapter is taken from a variety of sources, including government reports, SHASEA Project reports, interviews and conversations with farmers, local political leaders, extension agents and SHASEA Project researchers and group discussions. Although this study was undertaken at the end of the Project, an attempt has been made to describe conditions before the start of the Project.

3.1 Geographical and demographic features

Kelang village is situated approximately 67 kilometres north east of Kunming, the provincial capital of Yunnan, and is part of Xun Dian County. The total area of Kelang is 8 km² (Kelang Village Authority, 2002). Approximately 79.2% of the cultivable land in Kelang village is on sloping land, with slope angles ranging from <8° (8.9%), 8-15° (13.7%), 15-25° (37.4%) to >25° (39.3%) (Li YongMei, 2004). The altitude of the fields around the village ranges from 1716-2163 m (SHASEA, 2003). The village settlement is situated along the border of the sloping uplands of the Wang Jia catchment and an extended area of paddy fields along the basin of the Kelang River (Plate 3.1).

Plate 3.1 Kelang village. (Source: Author)

Other settlements situated near Kelang village are Mosu (~3 km towards the south east), Xin Sha and Sha Zhang villages (~2 km south of Kelang village). At the start of the SHASEA Project, Kelang was more prosperous than the neighbouring villages. The total population of Kelang village in 2001 was 3648 (860 households) of which approximately 49% were dependent primarily on agriculture for their livelihood (Table 3.1).

Table 3.1 Population and area of Kelang Village in relation to China, Yunnan Province and Xun Dian County.

Parameters	**China**[1]	**Yunnan Province**[2]	**Xun Dian County**[3]	**Kelang village**[4]
Total population	1,259,090,000	41,924,000	486,447	3,648
People depending on agriculture	870,170,000	18,818,000	458,002	1,800
Total land area (km^2)	9,600,000	394,000	3598	8
Cultivable area (ha)	94,970,000	57,169,400	36,221	162

Sources: 1 = (Editorial Board, 2000b); 2 = (Editorial Board, 2000a); 3 = (Zhu Baoshen, 2000); 4 = (Kelang Village Authority, 2002).

3.2 Major historical events of Kelang Village

Kelang is a fairly old village. Settlement in Kelang started more than 1000 years ago, before the *San Kuo* period (*San*-three and *Kuo*- kingdom or state) (Stokes and Stokes, 1975; Yong and Arthur, 1975; Rodzinski, 1979). However, development of the existing major infrastructure started only in the 1960s. The Kunming-Kedu road, built in 1972, passes through Kelang village linking both the provincial capital (Kunming) and the township headquarters (Kedu). The road link to the county headquarters (Kelang - Xun Dian County road) was constructed in 1980 as a mud road and tarmaced in 2001 (Shang Kaihua and Yang Xinghua, 2002, *pers. comm.*). The first electricity facility in the village was established in 1975 and the village received telephone lines in 1968.

A school was established in the village before the revolution (before 1949), but the village received a hospital service only in 1957. Being an old village, there was an organised market established before the revolution. However, the business of modern and improved agricultural inputs (seeds of improved crop varieties, significant use of chemical fertilisers, insecticides and pesticides and modern agricultural tools) started around 1978. The village has not witnessed any significant incidences of migration in the past. In 1968, approximately 10 households migrated into the village, but there has been no significant out-migration.

A severe drought in 1972 was recalled as the worst time in the recent history of the village; as a result there was no production of tobacco and maize (the major summer season crops) in the village. The years 1996-97 were remembered as the best for agricultural production, during which farmers received very good returns from agricultural crops because of the favourable growing conditions, in particular early and adequate rainfall to coincide with the planting season. There has been an increasing trend in the incidences of flooding over the last 20 years (Shang Kaihua and Yang Xinghua, 2002, *pers. comm.*).

Farmers' interests and participation in off-farm employment have increased, starting from the early 1980s. This period coincides with the change in Government policy from centralised production systems to household production systems (Li, 2000), after which personal enterprise was encouraged and personal property allowed. Farmers became free to choose and change their occupation and they started to pursue options to improve their household incomes.

3.3 Governance

Administratively, Kelang village is under Kedu Township of Xun Dian County in Yunnan Province in China. Four village political leaders constitute the Village Committee (Authority). Before 1999, the Township Party Committee used to select the village leaders. After 1999, the system changed to one in which three leaders (one Director and two Vice-Directors) were elected by local people. The Director is responsible for the overall administration and productivity and two Vice-Leaders are responsible for birth control and forestry. The fourth leader is Party Secretary and is appointed by the Township Party Committee and responsible for Party affairs. A Copy Clerk oversees the village statistics. The village leaders are paid by township finances. Four other paid members are nominated by the Village Committee to serve the village.

Extension services are generally based at township level and are responsible for all the villages under the Township. In Yunnan Province, the Sales and Marketing Co-operatives (S&M Co-op), the Agricultural Technology Extension Station (ATES), the Science and Technology Commission (STC), the Tobacco Management Station (TMS), the Tea Development Station (TDS), the Veterinary Station (VS) and the Forestry Station (FS) provide technology extension services at Township level (Wang and Xue, 1999). The S&M Co-op is a Government enterprise responsible for its own profits and losses. According to Government policy, the S&M Co-op is exclusively responsible for supplying agricultural inputs, such as fertilisers, pesticides and plastic sheets. The ATES, STC, TMS, TDS, VS and FS are Government line agencies, responsible for distributing extension materials, such as improved varieties of crops or breeds of animals and new technologies of crop/animal husbandry (Wang and Xue, 1999). The extension agencies at Kedu Township provide services to Kelang, through the Village Committee, mobilising the village officials when required.

There is a tobacco purchase and sales depot of the Government of China in the village. The depot operates only during the tobacco growing season (April-August). It sells tobacco seed, fertilisers and polythene to farmers and purchases flue-cured (dried) tobacco leaves from them. Depot staff carry out their activities with the active assistance of village officials, particularly during the month-long tobacco leaf purchasing period.

3.4 Land use

Total cultivable land in Kelang village is 162 ha, of which paddy fields comprise ~20% (33 ha) and the upland area covers ~80% (129 ha) (Kelang Village Authority, 2002). Both food and non-food crops are cultivated in the village. Rice, tobacco and maize are the main crops (SHASEA, 2003) and tobacco is the only non-food crop grown widely in the village. Other cereals (mainly wheat), peas, beans and fruits are also grown, but to a lesser extent. Approximately 90% of the total output value comes from rice, tobacco and maize and farmers invest approximately 80% of their labour days for the production of these crops (SHASEA, 2003).

Maize is the main summer season crop and pea is the dominant winter crop in Wang Jia catchment (Table 3.2).

Table 3.2. Food crops grown in Wang Jia catchment, Yunnan Province, Household Survey, Summer 2002.

Crops	**Number of households growing the crops**
Summer	
Maize	63 (100%)
Soybean	13 (20.6%)
Potato	1 (1.6%)
Winter	
Wheat	29 (46%)
Pea	51 (81%)

Note: Numbers in parentheses are the percentage of total households surveyed.

Maize is grown either in monoculture plots or mixed with sunflower, French bean, soybean or pumpkin/marrow. The number of pea growing households was almost double that of wheat growing households. Rice is not grown in the catchment due to the absence of paddy areas. Similarly, tobacco is not grown following an agreement between farmers and village leaders to grow their quota outside Wang Jia catchment in Kelang village (Table 3.3).

Table 3.3. Major cropping patterns in Kelang village, Yunnan Province, China, PRA Survey, Summer 2002.

Cropping patterns (1 = most important)	
a. catchment	
1.	Maize + French bean - Wheat or Pea
2.	Maize + Soybean – Wheat or Pea
3.	Maize + Pumpkin - Wheat or Pea
4.	Maize + Sun flower - Wheat or Pea
5.	Maize - Wheat or Pea
6.	Maize – Fallow
7.	French bean – Wheat or Pea
8.	Soybean - Wheat or Pea
9.	Potato – Buckwheat
10.	Potato - Wheat or Pea
b. Outside catchment	
1.	Tobacco - Wheat
2.	Tobacco – Pea
3.	Tobacco - Wheat or Pea
4.	Tobacco – Fallow
5.	Tobacco + French bean or Soybean - Wheat or Pea
6.	Tobacco + French bean or Soybean - Wheat or Pea or Broad bean
7.	Tobacco + Soybean - Wheat or Pea
8.	Maize + French bean or Soybean - Wheat or Pea
9.	Maize + French bean or Soybean - Wheat or Pea or Broad bean
10.	Maize + French bean - Wheat or Pea
11.	Maize + Soybean – Wheat or Pea
12.	Maize - Wheat or Pea
13.	Maize - Wheat
14.	Maize – Pea
15.	Potato – Buckwheat

The inception of the household production system in China in 1982 resulted in remarkable changes in land use in Kelang village. Tobacco became a very popular crop, farmers expanded the area under tobacco every successive year and by 1998 the area under tobacco had doubled. After 1998 the tobacco area decreased due to a change in government policy (Table 3.4).

Table 3.4 Changes in the area under tobacco in Kelang village, Key Informant Survey, 2003.

Time period	**Area under tobacco**
Before 1982	Approx. 800 mu (53 ha)
1982-1993	Approx. 1000 mu (67 ha)
1993-1998	Approx. 1500 mu (100 ha)
1998-2003	Approx. 1300 mu (87 ha)

The tobacco produced in Yunnan Province is considered of high quality in China; as a result Yunnan tobacco fetches comparatively high prices. However, the Government of China adopted a policy to reduce tobacco production by allocating quotas so that, after 1998, farmers can grow tobacco in only limited areas. The quota is being progressively reduced each year. This caused a decline in agricultural income during 1998-1999. At present, agriculture is no longer the primary source of income for farming households. The contribution of agricultural income to the total household income declined from >70% in 1995 to <30% in 1999 (Fullen *et al.*, 2002). In this context, there has been a need for better maize-based cropping technologies in order to reduce the income deficit due to progressive reduction in the areas under tobacco. Consequently, the Government of China adopted a regional policy to increase the production and productivity of maize, wheat and soybean, which underpinned the objectives of the SHASEA Project.

3.5 Security of tenure and stewardship

More sustainable farming technologies typically include long-term investments, for example terracing, tree/hedge/grass planting, run-off control and soil fertility improvement. Many of these investments do not accrue benefit in a short period of time. Farmers need assurances that they will be able to reap the benefits in order to be encouraged to improve land resources (Pandey, 2001). Security of right to use the land (land tenure) provides such assurances to farmers. Investment for soil conservation measures, especially terracing, is unlikely without the security of land tenure (Critchley *et al.*, 2001).

In China, private land ownership existed prior to 1949 (Chengri Ding, 2003). Land reform was launched after 1949 to reduce social inequality. By 1958, all farmland was owned collectively, while urban land was owned by the state (Yang and Wu, 1996; Zhang, 1997; Zhao *et al.*, 1998 as cited by Chengri Ding, 2003). Farmland was distributed to communes for collective production purposes. The household production responsibility system was introduced in the late 1970s and arable land was distributed back to farming households. Initially the farmland was allotted to farmers for 15 years. After that a 30-year extension of land tenure was made. The official decision for the extension was made during the early 1990s (the starting years vary geographically as the initial land contracts in the early 1980s were introduced at different times for different regions); however, the formal announcement about the 30-year lease policy was made only in 1998 (Li, 2000). Thus, production responsibility transferred from the brigade (*dadui*) and work team (*xiaodui*) to the family (*jiating*) (Sanders, 2000). This was a major change in the existing paradigm of agricultural production in China, due to this shift in Government policy. However, there is still considerable heterogeneity in land tenure policies at local levels throughout in China (Krusekopf, 2002).

3.6 Occupations/industries and income streams

Farming is the primary occupation of the people of Kelang village, even though it is not the main income provider. Many farmers have taken on part-time employment in off-farm activities, mainly because of small land holdings (average landholding = 0.19 ha/household) and decreasing incomes from agriculture (Fullen *et al.*, 2002). Construction works, retail businesses, catering, services, communication, transport and industry are the major off-farm occupations adopted by the farmers. Of the total household income, the proportion of income from agriculture was 67% for farmers from the poor wealth category, 45% for medium and 16% for rich categories (Section 3.7 and SHASEA, 2003). Upland areas contributed to <50% of the total on-farm income or 15% of the total income of the farming households (Fullen *et al.*, 2002). This indicates that only a small proportion of the household income was from Wang Jia Catchment. Kelang is a fairly typical village in Yunnan Province and Wang Jia is a fairly typical upland catchment (Fullen *et al.*, 2002). The agricultural income in Kelang increased significantly between 1994 and 1997 to a maximum of 3.5 million Yuan and then declined sharply in 1998 and 1999 to 1.5 million Yuan (Fullen *et al.*, 2002; SHASEA, 2003). Tobacco was the most important single component of farm income until 1997.

3.7 Wealth categories

Farmers, in a group discussion, perceived that 17.5% of the surveyed households in Wang Jia catchment were in the poor category, 65% in the medium and 17.5% in the rich category (Table 3.5). The higher percentage in the medium wealth category shows low economic disparity among the surveyed households. It is interesting to note that the difference in food sufficiency level among wealth categories was not statistically significant ($\chi_4^2 = 0.735^{NS}$). This could be because the same size of the land was allocated to each farmer due to which farm production was similar among the farmers across the wealth categories. Therefore, off-farm income is the primary factor responsible for deciding the wealth category of the farmer. The overall economic status of the farmers in the village, as expressed by food sufficiency, was low, as 84% of the farmers produce food just sufficient for one year or less (Table 3.5).

Table 3.5. Food sufficiency level and wealth category of the surveyed households in Kelang village of Yunnan Province, Household Survey, Summer 2002.

Wealth Category	**Food sufficiency level**			**Total number Of households**
	<6 months	**6-12 months**	**>12 months**	
Poor	3	7	1	11 (17.5%)
Medium	13	21	7	41 (65.0%)
Rich	3	6	2	11 (17.5%)
Total number of households	**19 (30%)**	**34 (54%)**	**10 (16%)**	**63**
χ_4^2	**0.735^{NS}**			

Note: NS = Not Significant at P<0.05 level.

Farmers had small and highly fragmented land in Wang Jia catchment. This could be one of the contributing factors to their low food sufficiency level. The surveyed farmers (n = 63) had an average landholding of 0.115 $\pm$ 0.009 ha (ranging from 0.100-0.333 ha) within Wang Jia catchment. On average, farmers' land was divided into 4.19 $\pm$ 0.42 parcels (ranging from 1-16 parcels) (Table 3.6). They also possess other land outside Wang Jia catchment. The results suggest that food sufficiency level (on-farm production) was not a strong indicator of wealth category of the farming households in Kelang village.

Table 3.6. Land holding (within the catchment) of the household surveyed in Kelang village, Yunnan Province, Household Survey, Summer 2002.

Wealth category	**N**	**Area (ha) $\pm$ SE**	**Number of parcels $\pm$ SE**
Poor	11	0.123 $\pm$ 0.0165	2.91 $\pm$ 0.48
Medium	41	0.116 $\pm$ 0.0107	4.51 $\pm$ 0.58
Rich	11	0.099 $\pm$ 0.0266	4.27 $\pm$ 0.95
Total	**61**	**0.115 $\pm$ 0.0088**	**4.19 $\pm$ 0.42**
Range	-	0.100 – 0.333	1-16
F	-	0.348^{NS}	1.000^{NS}

3.8 Summary and conclusion

From the socio-economic perspective, Kelang village was considered to be fairly typical rural village and from a geomorphopedological point of view, Wang Jia represents a typical upland catchment in Yunnan Province (Fullen *et al.*, 2002). The pace of change in the livelihood strategy of farming households in Kelang village, however, may not necessarily be the same as other villages in Yunnan Province. The contribution of agriculture to the total household income of Kelang village declined from 70% in 1995 to 30% in 1999. Off-farm employment is the major source of income in Kelang village, which contributes >70% of household income. This is due to good opportunities for off-farm employment, both in Kelang and Kunming, the nearest city. In addition, there is a high degree of preference for off-farm income among the economically active adult population. There is a very strong, positive correlation between the level of household income in Kelang village and engagement in off-farm employment (Fullen *et al.*, 2002). Increases in household income are likely to have one or more of the following effects:

- Increased purchasing power of the farmers for improved tools and inputs.
- Increase in buffering capacity against reduced household income. Such farmers can wait for the income from long-term investment, i.e. are capable of investing for long-term options such as tree planting.
- Less dependency on agriculture leading to less pressure on land
- Farmers have less interest in investing extra efforts in improving the land, as it is not their primary source of livelihood

Not many villages have the same level of off-farm employment opportunity. So, despite the Kelang appeared to be a typical rural village of Yunnan, the difference in household incomes from off-farm employment will pose limitations in generalising its socio-economic aspects.

Kelang is a fairly old village. In comparison to other villages, it has better development structures (hospital, school, drinking water, electricity, telephone lines, market, and some Government offices) and economic opportunities (employment opportunity, business/trade opportunity).

Most of the cultivable area in Kelang village is occupied by sloping uplands. Maize was the main summer season crop and pea the dominant winter crop in Wang Jia catchment during the period of study. All farmland belongs to the Government in China, which has been leased out to individual households for 30 years with effect from 1998. Three distinct wealth strata were found among the farming households in Wang Jia catchment, of which 17.5% of households were in the poor category, 65% in the medium and 17.5% in the rich category.

Chapter 4 - The SHASEA Project

(***Note:*** *The information in this chapter has been extracted from SHASEA, 1997; SHASEA, 2000; Fullen et al., 2001; Huang BiZhi, 2001; Milne, 2001; SHASEA, 2001; SHASEA, 2002a; SHASEA, 2003; Wang ShuHui, 2003; Li YongMei, 2004; Liu HongMei, Thesis in prep.)*

4.1 Introduction

An integrated SHASEA (Sustainable Highland Agriculture in S.E. Asia) Project (EU Contract Number: ERBIC18CT980326) was focussed primarily on Yunnan Province, China, with a secondary site in North Thailand. The aim was to improve agricultural productivity and sustainability of cropping systems in highland regions of South-East Asia (Figure 4.1).

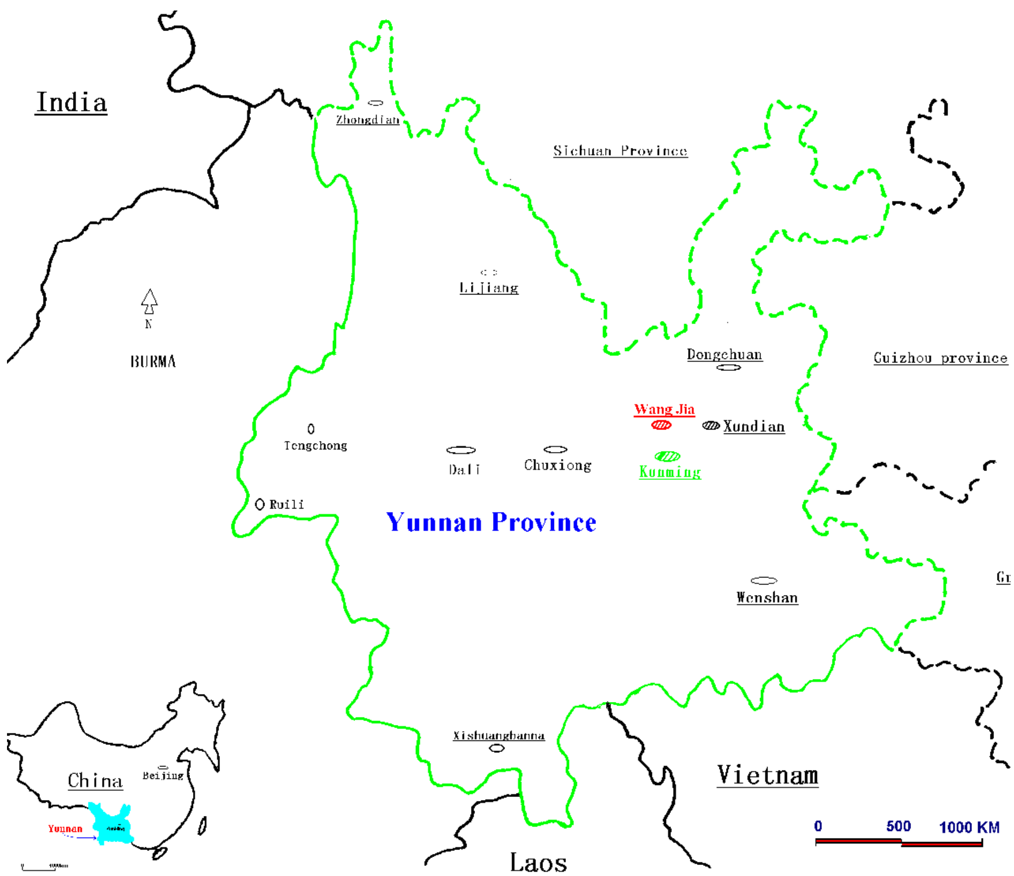

Figure 4.1 Location of SHASEA Project site.

This programme had the specific objectives of implementing and evaluating practices to increase the productivity of maize, wheat and soybean on fragile slopes in a sustainable and environmentally friendly way. The approach incorporated modified and novel agronomic and soil conservation measures, evaluating the agricultural, environmental and socio-economic impacts of these measures using multidisciplinary approaches. This EU-funded INCO-DEV project involved a collaborative research team from Belgium, Ireland, U.K., China and Thailand. A longer-term aim was to use the modified cropping systems developed in a catchment north of Kunming as a demonstration area and training model for sustainable agricultural development in the South China highlands. A parallel study, restricted to scientific evaluation of agronomic and physico-chemical impacts, was carried out in plot studies at Pangmapa, in the highlands of North Thailand, testing the broader applicability of the cropping practices being developed for S.E. Asia.

4.2 Background to the SHASEA Project

Yunnan Agricultural University and the University of Wolverhampton started collaborative studies in 1990. The objective of the initial studies was to develop improved cropping practices to reduce water run-off and soil loss on sloping land in Yunnan Province. Losses of soil, water and soil fertility were identified as one of the main reasons for decreasing agricultural production and environmental degradation in the cultivated sloping uplands of Yunnan Province. Research scientists at Yunnan Agricultural University (YAU) also recognised that the existing, traditional cropping practices were unsustainable. Crop yields on sloping land in South China had decreased by 30-60% because of soil erosion (Gao Zhu and Zhou Lie, 1988). If current erosion rates continued, most of the topsoil would be removed in 50-100 years (Shi Deming, 1987). On the one hand, degradation of natural resources was accelerated due to indiscriminate agricultural intensification, while on the other, rapid industrialisation and urbanisation, along with strong demands for increased food production, were exerting pressures on land use in these fragile areas. Effective soil conservation measures were necessary to achieve more sustainable increases in productivity on hillslopes (SHASEA, 1997). The YAU scientists therefore joined up with a UK team working in China on soil erosion to develop plot-based studies to evaluate novel or improved cropping practices designed to reduce runoff and soil loss.

Erosion plot studies were conducted on the experimental farm of Yunnan Agricultural University during the first phase of the study. The plots were used to measure runoff, erosion rates and crop productivity. The plots were used each year during 1993-1999, with the programme jointly funded by the British Council (South China) and Yunnan Science and Technology Commission. Two M.Sc. and two Ph.D. studies were completed during 1996-98 using the plots. Those studies identified the benefits of straw mulch and contour cultivation for soil and water conservation. The research outcomes were very effective for soil conservation. However, the effect of the technologies on crop productivity was not consistent. Before extrapolating technologies generated from plot studies to the wider scale, it was necessary to understand:

- How these technologies would work in farmers' fields?
- How would farmers adopt/adapt these technologies?
- Would farmers use these soil conservation technologies if there were no increases in productivity?

The output from the plot study was then evaluated in farmer-managed plots in a catchment. The project was implemented with funding support from the Department for International Development (DfID), UK and the British Council, UK. The objective of the project was to link soil conservation technologies to agronomic practices designed to improve productivity. Wang Jia Catchment was chosen to implement these activities, with the aim of developing a study area for long-term research at the catchment level.

For this relatively small-scale field evaluation, polythene mulch was included as a simple way of improving productivity, which proved to be successful in significantly increasing maize yields. However, it was most effective only if the polythene was applied after irrigation, as infiltration of rainwater was largely eliminated by the polythene. Consequently, the project scientists devised a technique of planting maize in the furrow between the two ridges covered in polythene, allowing the rainwater to infiltrate down through the opening around the maize stem. This led to the development of the INCOPLAST (Integrated contour cultivation, plastic and straw mulch treatment) system for improved soil and water conservation and enhanced crop productivity. This technology was used in the SHASEA Project. It was envisaged that it would optimise effectiveness in terms of improving early season growth, canopy development and ground cover, leading to increases in productivity.

The Project team then started planning an EU project, to enlarge the study to the full catchment scale. At this stage the team initiated discussions with the village and township officials to gauge how they would wish to improve cropping practices in the catchment. Initially, local officials were less concerned about soil loss and runoff, rather their priorities were focussed on:

- An irrigation system to improve early season establishment of summer crops and improve winter (dry season) cropping.

- Engineering works to stabilise gullies, regulate flow of the stream through the catchment and prevent flash floods into the village.
- Development of perennial cash crops to increase income, while reducing the requirements for repetitive cultivation.

These developments coincided with the separate identification of regional priorities by the Government of China to enhance the productivities of maize, wheat and soybean. Therefore, the SHASEA Project was finally developed by incorporating the regional priorities, villagers' preferences and the scientific outcomes from the previous projects, implemented in Wang Jia catchment. This involved the twin goals of increasing both crop productivity and sustainability of upland cropping systems in S.W. China. Thus the Project was a mixture of international, regional and local inputs and priorities, embodied within a holistic catchment-scale study.

The research operated under the 'Scientific and Technological Co-operation with Developing Countries' Programme of Directorate General (DG) XII in Brussels, which had responsibility for science and technological development within the European Union. DGXII allocated 650,000 Euros to the Project.

4.3 Expected outcomes

These were as follows:

a. a complete scientific study and evaluation of the effects of novel combinations of cropping and cultivation systems on the productivity of key arable crops (wheat, maize and soybean), with enhanced sustainability in fragile highland areas in S.W. China; an evaluation of the feasibility of applying selected techniques to the highlands of North Thailand;
b. evaluation of the socio-economic effects of recommended cropping strategies, including their applicability, acceptance, benefits and development implications at the individual farm level and their impact on the wider community (village, township, province and region);
c. the full establishment of a functional integrated catchment study, which would serve as an observatory and model and be maintained as a long-term research, training, extension and demonstration facility, subject to the availability of funding; a longer-term management plan for the catchment was to be agreed, on which further actions and recommendations for wider adoption and adaptation would be based;
d. international dissemination of research information and technology;

e. the relaying of recommendations and information directly to local farmers and farm workers in a culturally-acceptable manner (open days with field visits by local farmers, educational booklets for farmers and training for agricultural advisers in Yunnan); due to the timescale of the research, this outcome was intended to continue beyond the funded period of the programme.

4.4 The project site - Wang Jia catchment

The SHASEA Project was implemented in the Wang Jia catchment of Kelang village within Kedu Township in Xun Dian County, North East Yunnan. Wang Jia catchment is situated at 25°28' N latitude and 102°53'E longitude. The altitude of the catchment ranges between 2044-2191m asl. The total catchment area is 40.1 ha, of which 27.3 ha of sloping uplands is suitable for cultivation, 1.1 ha is covered by sweet chestnut trees, 0.4 ha by rocky land, 9.5 ha by forest trees and 1.8 ha by barren hills (Fullen *et al.*, 2001). The upper part of the catchment is covered by forest. Sweet chestnut has been planted on the lower elevation of the forest. The cultivated area is located in the lower areas. There is a spring at the upper part of the catchment, which has a small discharge all year round. The climate of the catchment falls under the sub-tropical monsoon climate zone, with a mean annual rainfall of 1043 mm. The distribution of rainfall is uneven. The major proportion (80%) of rainfall occurs between June and October, with a dry period between November and May (a period of moisture stress for the winter crops). The average temperature of the area is 15°C, and 122 days in the winter are frost prone (243 days frost-free). The average annual sunshine in the catchment is 2082 hours.

4.5 Development of the research team

The research team comprised scientific experts from partner institutions and development experts from local partner institutions of the host countries. The area of involvement by each partner institution is given below. International exchange and capacity building was enhanced by reciprocal visits among the partner institutions.

- Soil scientists, crop physiologist and hydrologist from The University of Wolverhampton, U.K.
- Soil mineralogist from The Macaulay Land Use Research Institute, Aberdeen, U.K.
- Socio-economists from The National University of Ireland (Galway), Ireland.
- Soil scientists from Gembloux Agricultural University, Belgium.
- Agronomist, soil scientist and socio-economist from Yunnan Agricultural University, P.R. China.

- Local political leaders from The Government of Kedu Township, P.R. China.
- Soil scientists from Chiang Mai University, Thailand.
- Assistants and research students from partner institutions.

4.6 Activities and methodology

The Project was divided into five work packages (WPs), which addressed the following areas (see SHASEA, 2003 for detailed information):

Work Package 1: Agricultural and Environmental Assessment of Wang Jia Catchment. Activities under WP1 were co-ordinated by Gembloux Agricultural University (GAU), Belgium. The activities included the measurement of current productivities of maize, wheat and soybean on fragile slopes in both catchments, plus identification and semi-quantification of soil erosion processes. An environmental assessment of the catchment was also completed.

Work Package 2: Implementation and Evaluation of Modified and Novel Cropping Systems. Activities under WP2 were co-ordinated by Yunnan Agricultural University (YAU), China. Activities included the implementation and evaluation of modified and novel crop practices designed to increase crop yields and reduce soil erosion on fragile slopes at the research sites in both China and Thailand.

Work Package 3: Evaluation of the Socio-Economic Effects of Cropping Systems.
Activities under WP3 were co-ordinated by The National University of Ireland, Galway (NUIG), Ireland. Activities included the initiation of the assessment of the environmental impacts of the changed practices on Wang Jia catchment and the socio-economic impacts on the adjoining village of Kelang.

Work Package 4: Comparative Evaluation of Cropping Practices to Improve Soil Productivity on Highland Slopes in Thailand. Activities under WP4 were co-ordinated by Chiang Mai University (CMU), Thailand. The activities included the parallel evaluation of modified and novel crop practices designed to increase crop yields and reduce soil erosion, using sloping plots at a field site in Pangmapa, North Thailand (Thai component of WP2).

Work Package 5: Information and Technology Dissemination. Activities under WP5 were co-ordinated by the University of Wolverhampton (UoW), U.K. The activities included the initiation of the dissemination of Project outcomes (Figure 4.2).

4.7 Results achieved

A summary of the outputs reported in various project reports is presented in the following section. Only some of the selected results that are relevant to this study have been presented and discussed below in detail in this chapter. Details of the project results are given in the Final Report of the Project (SHASEA, 2003), a summary of which (Consolidated Scientific Report) is presented in Annex 4.1.

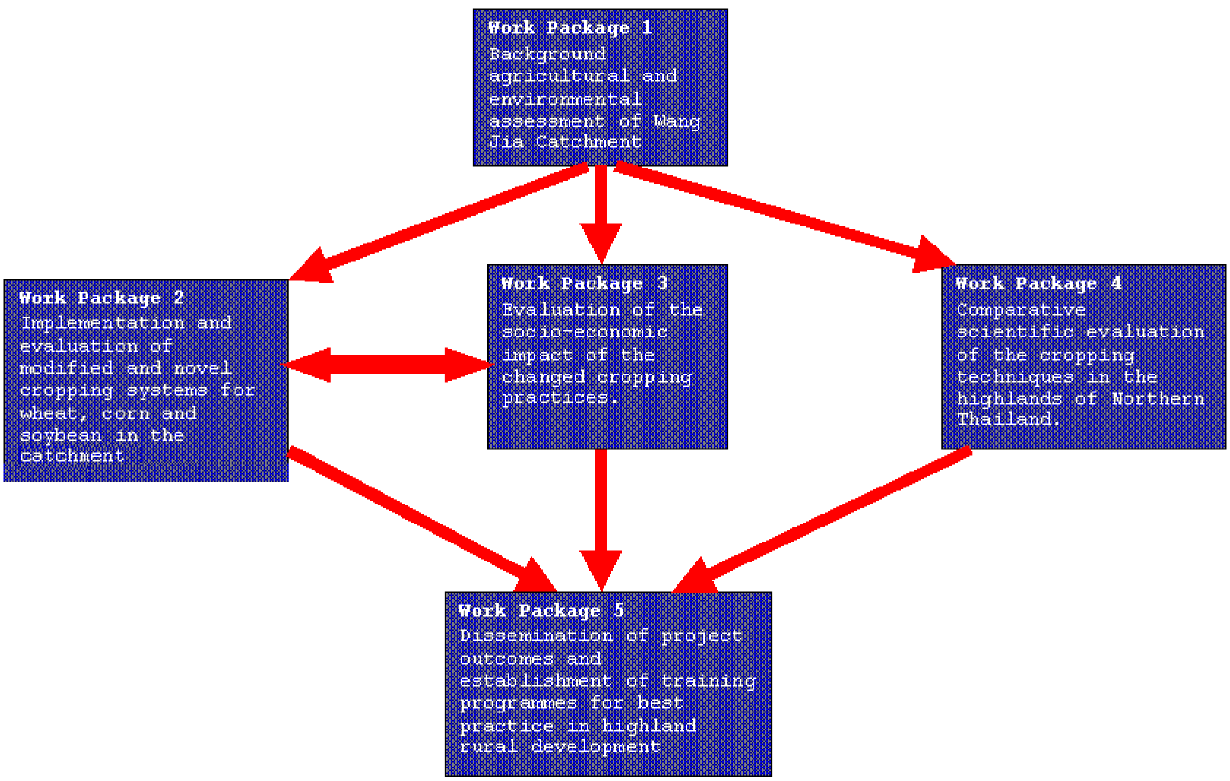

Figure 4.2 Work Packages of SHASEA Project.

4.7.1 WP1 - Agricultural and environmental assessment of Wang Jia catchment

The main results achieved included the improvement of the existing topographic map to produce a digitised catchment map, georeferenced in the UTM projection system, which is the base document for all the thematic maps produced, such as the land use map and the plantation map.

The representativeness of Wang Jia Catchment was evaluated by comparing its geomorphological and land use characteristics with those of the whole mountainside south of Kelang village, in which it is located. Detailed chemical and mineralogical analyses of Yunnan Agricultural University experimental farm and Pangmapa soils and a comparison with those from Wang Jia were made. Mineral magnetic properties of soils from Wang Jia catchment were also determined.

4.7.2 WP2 - Implementation and evaluation of modified and novel cropping systems

The engineering works, gully stabilisation and construction of irrigation reservoirs were successful in reducing runoff and sediment losses (Table 4.1) and floods in the catchment, improving safety both in the catchment and village. However, the information presented in Table 4.1 is only a function of the dams and gully stabilisation above the hydrological gauging station. The measurements were taken at the station, which was constructed in the gully at the base of the catchment.

Table 4.1 Variations in soil loss and runoff in Wang Jia catchment from 1998 to 2002.

Year	Rainfall (mm)	Rain events	Runoff (mm)	Runoff/rainfall (%)	Sediment (t/ha)
1998	1044.8	140	299.4	28.66	294.28
1999	900.8	141	79.4	8.81	12.76
2000	727.8	151	59.0	8.11	14.17
2001	939.6	185	71.9	7.65	13.24
2002	924.8	121	52.7	5.69	9.19

Note: Dams were built in May 1999 and the trees were mostly planted in 2000.
(Source: (SHASEA, 2003).

Improvements in crop productivity were made possible with the construction of the irrigation scheme, in conjunction with the modified cultivation practices. Field experiments in Wang Jia revealed that irrigation improved early vegetative growth and final yields when early season rainfall was unreliable, as the maize yield was increased by 39.5-59.6% in 1999 compared with the corresponding non-irrigated treatments (Table 4.2) (Huang BiZhi, 2001).

Scientific evaluation of cultivation practices for improving the productivity of maize remained the primary focus of WP 2. These practices were selected and developed from treatments evaluated previously in erosion plots for their effectiveness in soil conservation. These were: (i) traditional cultivation with downslope planting (D); (ii) traditional cultivation with contour planting (C); (iii) traditional cultivation with double ridge contour planting and polythene mulch

(C+P); (iv) traditional cultivation with double ridge contour planting, polythene mulch and straw mulch (C+P+S) (INCOPLAST); (v) traditional cultivation with contour planting, polythene mulch and intercropping with soybean (C+P+IS). The yield responses of maize to various treatments are presented in Table 4.3. All the tested technologies were superior to farmers' traditional practices in terms of grain yield. The average yields from C, C+P, C+P+S, C+P+IS were respectively 11%, 36%, 36%, and 32% higher than D (Wang ShuHui, 2003) (Table 4.3).

Table 4.2 Maize yield (t/ha) at Wang Jia Experimental Site during 1998 and 1999.

Year	**Yield Determination**	**Treatments**				
		T+D	**T+C**	**T + C + St**	**M + C + St**	**T + C + P**
1998	Yield from sampled plants	5.7	7.4	6.5	6.5	8.2
	Yield from plots	4.3	5.4	5.0	4.9	5.7
1999 Unirrigated	Yield from sampled plants	5.7	6.6	6.7	7.2	8.3
	Yield from plots	5.3	5.38	6.2	6.4	7.6
1999 Irrigated	Yield from sampled plants	6.7	7.3	7.5	6.9	10.2
	Yield from plots	6.0	7.2	7.3	6.1	9.1

(Source: Huang BiZhi, 2001).

Note: T+D: Traditional tillage + downslope planting.
T+C: Traditional tillage + contour planting.
T+C+St: Traditional tillage + contour planting + straw mulch.
M+C+St: Minimum tillage + contour planting + straw mulch.
T+C+P: Traditional tillage + contour planting + polythene mulch.

Table 4.3 Effect of different cultivation and crop husbandry practices on the productivity of maize in Wang Jia Catchment, 1999-2001.

Treatments	**Grain yield (t/ha)**			
	1999	**2000**	**2001**	**Mean**
Traditional cultivation and downslope planting, no mulch (D).	7.3[a]	7.8	6.2[a]	7.1
Traditional cultivation and contour planting, no mulch (C).	8.1[a]	8.8	6.7[a]	7.8
Traditional cultivation and contour planting, with polythene mulch (C+P).	11.2[b]	9.5	8.3[b]	9.6
Traditional cultivation and contour planting, with wheat straw and polythene mulch (C+P+S)	10.8[b]	9.7	8.4[b]	9.6
Traditional cultivation and contour planting, wide and narrow row spacing, with polythene (C+P+IS).	10.2[b]	9.3	8.7[b]	9.4
F value	11.27	1.49	16.17	
P value	<0.010	0.276	<0.010	

(Adapted from Wang ShuHui, 2003).

Physical measurements suggested that the increased crop response may have been due in part to higher soil temperatures and improved soil moisture retention in the early season. Pre-irrigation in advance of the onset of the rainy season, followed by mulching was particularly beneficial. This enabled rapid crop development and thus higher crop yields. Furthermore, rapid development of vegetative cover, especially maize canopy closure, was highly beneficial for resource (soil, water and nutrient) conservation (SHASEA, 2003).

In addition to these scientific investigations, the effectiveness of the Project technologies was also studied in the farmers' fields under their own management systems. Crop productivity in the catchment was monitored throughout the project (1999-2002). The 100 selected study plots identified by the Project, representing the physical and biological variation in the catchment, were monitored throughout the Project. Results of the crop productivity survey showed that varietal diversity decreased sharply during 1999-2002, which was statistically significant (χ_{57}^2 = 333.025, P<0.001) (Table 4.4). Maize varieties DF4, HD4, Q3 and HD were the most widely grown varieties in the catchment (Li YongMei, 2004).

Table 4.4 Maize varieties grown in 100 window plots in Wang Jia Catchment during 1999-2002.

Year	**Number of**	
	Plots under maize	**Varieties grown**
1999	92	12
2000	81	12
2001	71	4
2002	97	3

This monitoring also revealed that farmers had used both downslope and contour cultivation methods in almost equal proportions in the past (Table 4.5). However, in 2002, more plots used the contour cultivation method. This was probably due to the Project's effectiveness in popularising the contour cultivation system. The difference was statistically significant (χ_{12}^2 = 105.717, P<0.001).

Table 4.5 Cultivation methods used in the 100 plots in Wang Jia Catchment during 1999-2002.

Cultivation method	**Number of plots**				
	1999	**2000**	**2001**	**2002**	**Total**
Downslope	46	55	36	1	138
Contour	50	29	44	96	219
Other/no row		1	4		5
Total	96	85	84	97	

Soybean and French bean were the most popular crops for intercropping in 1999; however the number of plots under soybean decreased after 1999. The general practice of using an intercropping system declined during 1999-2002 (χ_{12}^2 = 30.208, P<0.01); however there was a small increase in the number of plots under intercropping during 2002. The number of plots under intercropping systems was 46, 15, 7 and 20 during 1999, 2000, 2001 and 2002, respectively.

The use of polythene mulch for maize crops was very low until 2001, but increased significantly during 2002 (χ_3^2 = 136.046, P<0.001). Out of the 100 surveyed plots, the number of plots under polythene mulch was 17, 9, 9 and 80 during 1999, 2000, 2001 and 2002, respectively.

Mean grain yield of maize in the farmers' plots increased in 2002, which was significantly higher than in the previous three years (F=20.733, P<0.001, df=3) (Table 4.6). Most farmers used one or more of the project technologies in 2002, which could be the reason for overall increases in maize yield in the catchment. Overall maize productivity had decreased in the catchment during 2000 and 2001. In 2000, maize emergence in Wang Jia catchment was low, leading to poor canopy development and a reduction in overall production. In 2001, there was a severe hailstorm during early July, which destroyed the leaves of the maize plants. The time of the hailstorm coincided with the active grain-filling period of the crop and resulted in low yields in 2001.

The mean grain yield between the farmers' plots was also influenced by the wealth category of the farmer (F=6.155, P<0.01, df=2) (Table 4.7). The plots of the rich category had significantly higher yield than medium and poor categories.

Table 4.6 Mean grain yield of maize in 100 window plots in Wang Jia Catchment during 1999-2002.

Year	**Grain yield kg/ha**	
	Mean (±SE)	**Range**
1999	5401±173.7	1920-9040
2000	4954±171.6	1608-8444
2001	4410±170.3	909-9293
2002	6165±148.2	3511-10547

Table 4.7 Mean grain yield of maize in 100 plots in Wang Jia Catchment during 1999-2002.

Wealth Category	Grain yield kg/ha	
	Mean (+SE)	**Range**
Poor	5001+184.7	1555-8170
Medium	5216+109.0	909-9979
Rich	5996+252.4	2140-10547

4.7.3 WP3 - Evaluation of the socio-economic effects of cropping systems

The socio-economic study of Kelang village revealed that the village had moved from a heavy dependence (70% in 1995) to a low level of dependence (30% in 1999) on agriculture over a few years. This had been significantly influenced by Government policy to reduce tobacco production, agricultural prices and the availability of off-farm employment. However, agriculture was still the main source of income for some families (11% of the surveyed households in Kelang village).

The long-term impact of the integrated catchment management practices was expected to be positive, although there were net costs in the early years. However, the time preference of farmers is strong, particularly the poor farmers have a much higher time preference than richer farmers. This reveals that poor farmers want to have cash in hand, so that they can spend for immediate needs. They are reluctant to save the money for the future or invest for future benefit. This means that unless farmers can be persuaded of the desirability of environmental measures, or compensated for engaging in them, they are unlikely to implement them of their own accord.

4.7.3.1 Traditional cultivation methods

The traditional cultivation method in Wang Jia catchment is downslope; the main crops are maize, tobacco, wheat and peas. In summer, ~90% (24.57 ha) of land in the catchment is planted in maize and 10% (2.73 ha) of land in tobacco. In winter, 70% (19.11 ha) of land was planted in peas and 20% (5.46 ha) planted in wheat, while the rest left fallow.

4.7.3.2 Economic cost/benefit analysis for the new cultivation methods

Increased yields were obtained from the new tillage practices (Table 4.8). The effect of adopting different cultivation practices in terms of increased crop yields was considered using downslope cultivation (D) as the baseline. All new cultivation practices produced a higher net return than traditional cultivation (D).

Table 4.8 Economic Return of Different Cultivation Practices in the the Experimental Plots

Cultivation practice	**Output value (yuan/ha)**	**Material cost (yuan/ha)**	**Net return (yuan/ha)**	**Labour cost (mandays/ha)**	**Net return to labour (yuan/ha)**	**Relative to D**
D	5581.6	1417.3	4164.3	272	15	1
C	6172	1417.3	4754.7	294	16	1.14
C+P	7952.8	1964.9	5987.9	292	20.51	1.44
C+P+S	7790.4	2264.9	5525.5	298	18.54	1.33
C+P+IS	8319.4	2364.5	5954.9	298	19.98	1.43

(Source: SHASEA, 2003)

4.7.3.3 Evaluation of the tree planting

There is no financial benefit from cash trees such as sweet chestnut and prickly ash during the first five years. There is some benefit from these trees from the sixth to the tenth year, as the trees starts producing at their potential level after 10 years. Return from sweet chestnut is estimated at 463,554 yuan per year and for prickly ash at 110,052 in Wang Jia catchment. The repayment of the investment requires more than 10 years (SHASEA, 2003).

4.7.4 WP4 - Comparative evaluation of cropping practices to improve soil productivity on highland slopes in Thailand

A parallel study was carried out in the highlands of North Thailand to scientifically evaluate the agronomic and physio-chemical impacts of improved cultivation techniques. This WP tested the broader applicability of the cropping practices being developed for S.E. Asia. CRP (contour ridge cultivation with polythene plus straw mulch, INCOPLAST) was the best method for maintaining soil fertility, improving soil structure and retaining soil water, thus leading to the highest crop water use efficiency for biomass production, compared to CC (contour cultivation), CR (contour ridge cultivation without mulching) or AL (alley cropping). AL conserved most soil and water by reducing soil loss and runoff, while CRP induced higher runoff during the wet seasons, but effectively conserved soil water by reducing soil water evaporation during the dry period compared to CC or CR. AL was the most conservative method and the best practice for both improving maize yield and reducing runoff and erosion on highland slopes. CRP was the second best for maize yield production and soil conservation, but it was the best method for conserving soil water, giving the highest water use efficiency and lablab bean yield during the dry season.

4.7.5 WP5 - Information and technology dissemination

The research team adopted a balanced and integrated strategy for maximum information dissemination. Detailed plans agreed for *'information dissemination'* included a publication of research outputs in local media, agricultural journals and international conferences, followed by general papers in international refereed journals. Information on the **SHASEA** Project can be accessed on the World Wide Web. These pages were regularly updated during the Project period and the URL is: http://www.wlv.ac.uk/science/environment/SHASEA/

Four Ph.D. theses, 11 Masters theses and 12 B.Sc. theses associated with the Project have been completed. Another Ph.D. thesis is in progress. Papers reporting the research in South East Asia have been presented at national and international conferences.

A total of 60 publications were published during the project period (Table 4.9), which includes published articles in refereed journals, proceedings, book chapters, dissertations/theses, and project reports. The list of publications is presented in Annex 4.1.

Table 4.9 Publications produced by SHASEA Project.

SNo	Type of publications	Number
1	Published papers and proceedings	15
2	Theses • PhD • Masters • Bachelors	28 5 11 12
3	Other conference papers	8
4	Reports	8
5	Guidebook	1
	Total	60

(Adapted from SHASEA, 2003)

In the final year of the Project, the team organised the '*Workshop on Sustainable Highland Agriculture in South-East Asia* (**SASEA**)' in Yunnan, China. The main aim was to introduce the research findings of the Project to potential users. It targeted and integrated discussion between research users, policy-makers, the scientific research community, local farmers and extension workers and had two components: a post-Congress tour ('*Red Cloud Tour*') of the '17th World Congress of Soil Science', Bangkok, Thailand (August 14-21, 2002) and a workshop at Kunming, Yunnan Province. This aimed to promote the practical applications of the research for improving the productivity and sustainability of cropping techniques on fragile highland slopes in South-East Asia in an environmentally friendly way. To aid dissemination of Project research results, the team prepared the '*Red Cloud Tour Guidebook'*, plus an updated project pamphlet in English and Chinese and an instruction manual in Chinese. A series of field workshops was held in Wang Jia catchment from October 2000 during critical times in the cropping season. The results from field experiments were discussed and improved cropping procedures demonstrated. These workshops generated considerable interest and discussion.

4.8 Conclusions of SHASEA Project

The following points were presented in the final report as conclusions of the project (SHASEA, 2003). The scientific aims of the project had been achieved and, within this context, the Project could be considered a "success story". Specifically:

1. *"It has been demonstrated that the productivity of maize can be increased, by up to 50% compared to traditional methods, on sloping fragile land, using simple cost-effective technologies, which in parallel plot studies have been shown to improve soil and water conservation. A detailed scientific evaluation has been carried out in Wang Jia Catchment to quantify the effectiveness of these technologies and develop explanations of how the crop responses have been produced.*

2. *Improvements in maize cropping practices have been linked to the on-going development of a land management plan to achieve, in the longer term, a more sustainable agricultural system in Wang Jia Catchment. This plan has included a range of engineering measures to control erosion, the installation of an irrigation system to improve the level and reliability of crop yield, including maize and winter wheat, the planting of trees as cash crops (sweet chestnut and prickly ash) on the steeper slopes, the planting of pine on parts of the upper catchment to return that land to forestry and the development of a monitoring system to attempt to evaluate the effectiveness of these measures over the longer term. Discussions on the further development and maintenance of this plan are continuing.*

3. *The development of this land management plan has also been informed by a comprehensive survey and description of the biophysical characteristics of the catchment, which has provided a baseline for subsequent change and established the representativity of the catchment in relation to the surrounding area. The catchment has been shown to be representative of the mountainside where it occurs, and the soils at the different sites to be representative of red soils dominated by the influence of limestone and strongly affected by*

contributions from material further upslope. Such areas are extensive in the highlands of Yunnan Province and South-East Asia. The description and analysis of the site is ongoing, as the changes to the catchment proceed, and will be developed into a GIS-based land management and evaluation system for subtropical highland catchments, such as Wang Jia.

4. *Socio-economic analysis, which is also ongoing, has been used to determine the economic and social feasibility of the alternative cropping strategies, the wider implications of the land use changes and the likelihood of subsequent adoption and adaptation of the technologies employed. Moderately long (five years plus) perspectives are needed for investment programmes to yield dividends. Government assistance is needed for the farming community to achieve significant improvements in sustainability over this time horizon.*

5. *Scientific evaluation of selected cropping practices developed in Wang Jia has been carried out in North Thailand and has demonstrated that these practices are, in most respects, as effective as the best practices in use in that region. In the Thai context, alley cropping was particularly successful in terms of increased crop productivity and soil, water and nutrient conservation.*

6. *Dissemination and training activities for wider adoption of these practices and associated recommendations have been initiated, first through a series of workshops held in the catchment for farmers in Kelang village and subsequently in the form of training sessions for local government officials and other stakeholders.*

7. *Scientific training associated with the project outcomes has been achieved through a series of undergraduate, Masters and Ph.D. programmes.*

8. *Dissemination of the scientific outcomes of the Project has been achieved through presentations at a number of national and international conferences, a scientific tour of the catchment, a provincial workshop held at YAU and a series of publications and reports.”*

4.9 Summary and conclusions from this initial review of the SHASEA Project

The SHASEA Project was implemented in a catchment using watershed management approaches. The achievement of the natural resources management objective was approached through biological and physical means, while the improvement of crop productivity was pursued through the development of novel and modified cropping technologies. There was a good mixture of researchers and development agents in the Project team from local organisations to European institutions. However, unlike other sloping land management programmes implemented in other countries in S.E. Asia (Table 2.2), farmer participation in the SHASEA project was not very robust. There have been very few participatory programmes in China. The participation of farmers in the Project was limited to consultation, participation in training and field days and in initial testing/adoption of Project technologies in their own growing environment. One of the good aspects of the SHASEA Project is that it attempted to address the priority issue of the local Government by embedding the regional priority of improving maize based cropping systems into its main research and development agenda. International development assistances have been criticised for imposing their own research/development agenda on host countries/organisations rather than solving the problem identified by the hosts themselves. Often funding and technical assistance agencies tend to adhere to their own interests, priorities and procedures (Samoff, 2004).

The Project was able to carry out a comprehensive scientific evaluation, with very effective initial dissemination within the catchment. The technical outputs of the Project have been described as successful in achieving project goals. However, the evidence on farmers' adoption of Project technologies by the end of project was limited. The long term contribution of these technical achievements depends on the extent of farmers' adoption/adaptation of these technologies. Farmers' perceptions and their future intentions about the adoption of project technologies are important to translate scientific success into better environmental conditions in the catchment and improved production and household income. Judging the effectiveness of Project technologies in the longer term requires, therefore, a longer period of monitoring and more participatory work with farmers.

4.10 Objectives of the remaining part of the study

Having completed the first two approaches outlined in Chapter1, page 3, the main investigative component of this study involves elucidating the views of farmers and other stakeholders about the technologies implemented by SHASEA. The objectives for this third phase are as follows:

5. To determine the perceptions of local farmers (family households) on the effectiveness of the technologies introduced by the Project and the likelihood of their future adaptation and adoption, using both household surveys and participatory rural appraisal.

6. To determine the views of available local stakeholders on the technologies introduced by the Project, their initial impact, dissemination, possible extension, adaptation and adoption.
7. To complete an additional analysis, of the biological, environmental and economic impacts of the Project technologies, through further monitoring by field survey, direct observation and economic analysis.
8. To achieve a synthesis of the outcomes from the approaches identified above to obtain a more holistic view of the impact of the Project, its short-term outcomes and potential longer-term effectiveness in relation to future adaptation and adoption, leading to the final conclusions of the present study.
9. To identify good practices for the development, implementation and dissemination of similar projects in the future.
10. To identify the limitations of the present study and outline areas for future study.

4.11 Rationale for the choice of methodologies

SHASEA Project activities were expected to have impacts at three levels, viz. plot, household and community/catchment levels. The biological effects of the changed cropping systems at plot level were studied during the Project. Limited socio-economic analysis was carried out as part of SHASEA during the Project period, but much of the work is yet to be published. This independent study was designed to consider not only the socio-economic effects of SHASEA activities on household and community/catchment levels after the Project period, but also to study the likely adoption and adaptation of the Project technologies in future. A key part of this approach was to study these aspects from the perspective of the local stakeholders, especially the farmers. Therefore different survey methodologies were considered, taking account of the nature of the information required, the respondents and the purpose of the information. Extracting the views of these stakeholders, particularly farmers, is challenging in China, mainly due to difficulties in communication and the socio-political situation, so it was necessary to verify the information collected from one source with other sources. Consequently, a multi-approach participatory evaluation study was designed, involving different participatory tools/techniques, such as household interview, PRA group discussions, farmers’ workshops, discussions with key informants and subject matter specialists and direct observations.

Household survey: The magnitude of the effects at household level was likely to vary among households due to variations in factors affecting farming practice, such as economic status, input use and labour availability. The household survey (HHS) was used to study the effect of those project activities which were likely to have different impacts on the social and economic conditions of farming households. This was conducted by interviewing the household head and completing a questionnaire. This is one of the quickest and most reliable methods for studying household situations. The questionnaires were submitted to, and approved by, the School of Applied Sciences (SAS) Ethics Committee of the University prior to their implementation in the study. The questionnaires were designed to explore the effect of the Project activities on households and consider responses from different gender and wealth groups.

Participatory Rural Appraisal: The use of participatory group approaches was considered for the evaluation of the SHASEA Project activities and outcomes at a broader (community/catchment) level. PRA methods, such as group discussions, transect walks, farmers' workshops and field observations, were conducted with the active participation of farmers. The effects of the Project interventions on agricultural production and environmental conditions in the catchment and the socio-economic conditions of farmers are discussed. This is a very effective tool for sharing and analysing ideas, which can also be used to plan, accomplish and evaluate projects. It is a quick approach, so is time efficient and cost effective. Participants are encouraged to participate in the group discussion and all ideas are valued. This leads to thorough discussion and the generation of quality information with minimum errors.

Key Informant Surveys: Discussions with individuals were performed to study perceptions about Project accomplishments from the perspectives of different stakeholders (leading farmers, local merchants, researchers, extension agents, policy makers and YAU academic staff). They were also performed to collect information to validate that received from household surveys and group discussions.

Direct observation: In addition to the surveys of different stakeholders, studies involving direct observations and analyses were carried out to evaluate the SHASEA Project. This was done to generate information to complement the results from household surveys, PRA group discussions, Farmers workshop and discussions with stakeholders. Four different direct observation studies were done.

- The plot survey generated objective information to compare with the farmers perceptions gathered from other participatory studies.

- The tree survey was done to study the effect of tree-planting on the environmental conditions of the catchment.
- The diagnostic erosion survey is a non-destructive and time efficient approach to studying the diagnostic features of soil and water losses. It was not possible to establish permanent facilities to study soil erosion during the study period.
- A limited economic analysis was undertaken to complement and assist in the analysis of the perceptions of economic issues gathered from the stakeholders.

Chapter 5. Household survey

5.1 Introduction

Household survey is one of the three approaches which have been used for the evaluation of the effectiveness of the SHASEA Project. Evaluation using group approaches, key informants and field surveys are presented in Chapters 6, 7 and 8.

The household interview method was used to study the effect of those project activities which were likely to have different effects on the social and economic conditions of farming households. A range of agricultural technologies was evaluated and implemented in Wang Jia catchment. Different farming households were expected to have preference for different technologies, due to the diversity in their social and economic conditions. It was expected that this would be shown through differential preference of farming households for different technology and development interventions. Only those aspects in which individual households were likely to have different responses (for example, total cultivable area, use of technologies, plans for future adoption of technologies) were discussed in the household survey.

5.2 Methodology

Household surveys were conducted in June-October 2002 and July-October 2003. The survey in 2002 focussed on studying the farmers' perception of the Project. In 2003 the survey focussed on studying the initial adoption of Project technologies by farmers. A participatory wealth categorisation exercise was carried out before the household survey, details of which are presented in Chapter 6. Two major activities were carried out for the household survey:

a. *Household Survey of farmers' perception on the project activities:* The household survey was completed with the help of undergraduate students and lecturers of Yunnan Agricultural University. A questionnaire survey was administered to the households, who were cultivating one or more of the 100 monitoring plots (farmers' plots used by the Project for monitoring implementation) in Wang Jia catchment and were involved in technology testing by the Project (Li YongMei, 2004). The 100 plot owners were surveyed, so that the farmers' perception and the researchers' findings could be compared. In 2002, all 63 farming households who owned the 100 monitoring plots were interviewed, while 61 farming households were interviewed in 2003. Two households were not interviewed in

2003. One householder had started a business in Kunming City and was unavailable. Another refused to give an interview, for which there was no clear reason.

b. *Household survey on adoption issues:* A separate household survey was conducted to study the adoption of Project technologies. The level of awareness, testing and adoption of Project technologies was studied by quantifying the number of farmers who were aware of the Project technologies, who tested the project technologies and were willing to use the Project technologies in future. The extent of dissemination of the Project technologies from the centre of its origin (i.e., introduction and testing) was also studied by administering the household interviews with three distinct categories of farmers,

- *Plot owners:* farmers with whom the Project team worked closely during the technology evaluation and testing phase. This group of farmers were involved in early testing of the technology in their own field and involved in several training workshops. All 61 farmers who own one or more plots among the 100 monitoring plots were interviewed.
- *Other farmers within the catchment:* other farmers of Wang Jia catchment who did not have any of the 100 monitoring plots and were less involved in Project activities during the technology testing and evaluation process. Awareness, level of testing and willingness for future adoption was compared with plot owners, and 32 farmers were interviewed from this category. Out of 152 households in the catchment, 32 households, excluding plot owners, were interviewed for this study. The attempt to select the households randomly was constrained by the availability of farmers' time during the survey period. So the first 32 farmers who were available at home were interviewed.
- *Farmers from outside the catchment:* farmers from outside Wang Jia catchment who were not involved in project activities. To study the extent of the dissemination of project technologies, the awareness, level of testing and willingness for future adoption of farmers from outside the catchment was studied in comparison with farmers from inside the catchment. Some 32 farmers were interviewed from Xin Sha and Sha Zhang villages (two adjoining villages, 1 km away from Kelang village), whose land was located in neighbouring areas (1-2 km) outside the catchment. Four interview teams visited the Xin Sha and then Sha Zhang villages at the same time and then the teams dispersed to different areas of the village to carry out interviews. Each team comprised 2-3 enumerators. The first 32 farmers who were present at home during the survey period and available for the survey were interviewed for this study.

The household head or the person responsible for farming was interviewed, so the choice of male or female farmers for interview was dictated by their position in the family or role in farming activities. Details of the activities conducted are outlined in Annex 5.1.

5.2.1 Preparation

Before launching the survey, a questionnaire was prepared and translated into Chinese (Annex 5.2). The questions were discussed in a meeting with other Project scientists and minor changes in the questionnaire were made following the discussion. The questions and data collection methods were also discussed in detail with enumerators, in four sessions. Social survey techniques and some social survey guidelines were also discussed during the meeting with enumerators. Then practice surveys were conducted by interviewing farmers who were not real respondents of the study.

5.2.2 Execution

The survey period coincided with a busy period for the farmers. So the survey was done primarily in the early morning, during lunch and dinner time, when the farmers were at home (Plate 5.1). Due care was taken to complete the individual survey within a reasonable length of time to avoid unnecessarily holding the respondents (farmers) away from their farming duties. The survey was conducted by 2-3 groups of enumerators simultaneously. The principal researcher followed each group in rotation in order to study the enumerators' work and their confidence and understanding of the questions. The surveyed questionnaire was checked in the field and any error in the survey and/or data recording was corrected by revisiting the farmer. The survey was carried out during 8-12 and 15-19 July 2002 and 21-25 July 2003. The farmers' circumstances during these two years of the study period could have been different leading to possible anomalies in the responses which will be considered when they arise.

5.2.3 Post-survey analysis

Survey results were recorded electronically performed soon after the completion of the survey. The data were checked for errors in data entry. Use of statistical analytical tools was determined according to the type of data. In the case of farmers' descriptive responses to open ended questions, the frequency of responses was calculated and presented in Tables without going through the rigour of statistical analysis. But analysis was performed for quantitative and semi-quantitative data and relevant statistics presented in Tables. Chi-square tests were performed to test the significance of categorical data, while one-way Analysis of Variance (ANOVA) was performed in the case of continuous data. In other cases, simple descriptive analysis was done. SPSS and Excel Software packages were used for statistical analysis. Preliminary analysis of the information obtained from field studies was conducted in China during the field study. Detailed analysis of information was performed in Wolverhampton, upon completion of field studies.

Plate 5.1 Interview during the Household survey with the farming families in Kelang village in Yunnan Province, 2002-03. (Source: Author)

5.3 Results

5.3.1 Effectiveness of project technologies

5.3.1.1 Cultivation method

The household survey revealed that of farmers who owned land both inside and outside the catchment, 100% cultivated across the contour inside the catchment but only ~78% did so outside the catchment during Summer 2002 (Table 5.1). This was attributed to the promotion of this technology within the Project, leading to higher adoption. The difference among the wealth categories for the use of different cultivation methods was not statistically significant (χ_4^2 = 6.66, P = 0.155), suggesting the choice of planting system was not dictated by household wealth.

Table 5.1. Cultivation practices used by farming households in and outside Wang Jia catchment, Household Survey, Summer 2002.

Wealth category	**Within catchment**	**Outside the catchment**			
	Contour	**Downslope**	**Contour**	**Both**	**Total**
Poor	11	1	6	4	11
Medium	41	4	33	4	41
Rich	11	0	10	1	11
Total	63	5	49	9	63
χ_4^2	-	6.66^{NS}			

Note: NS = Not Significant at P<0.05 level.

The majority of the surveyed farmers (87%) expressed their preference for contour cultivation (Table 5.2). There were differences among the farming households for the preferences of cultivation method, however, the choice of cultivation method was not significantly influenced by the wealth category of the farmer (χ_2^2 = 2.04, P = 0.361, Table 5.2). This indicates the majority of farmers from across the wealth categories preferred the contour cultivation method compared to downslope.

Table 5.2. Farmers' preference for different planting systems by wealth categories, Household Survey, Kelang Summer 2002.

Planting system	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
Downslope planting	2	6	0	**8 (13%)**
Contour cultivation	9	35	11	**55 (87%)**
Total	**11**	**41**	**11**	**63**
χ_2^2 (Wealth Category)	**2.04^{NS}**			

Note: NS = Not Significant at P<0.05 level.

Reasons for choosing any particular cultivation method were discussed in order to understand the farmers' criteria for the selection of particular cultivation methods. This was an open question (question without choices of possible answers). The possible reasons were not prompted, in order to avoid the possible imposition of the researcher's ideas before the farmers' responses. The majority of surveyed farmers chose contour cultivation because of 'better soil, water and nutrient conservation' (76%), followed by 'ease of cultivation' (29%), 'good for air movement' (21%), 'easy for weeding' (11%) and 'increased crop yield' (8%), respectively (Table 5.3). Farmers were capable of articulating the different types of advantages of contour cultivation, most of which were related to system sustainability, crop husbandry and crop production.

Table 5.3. Reasons for farmers' preference for a particular planting system, Household Survey, Kelang, Summer 2002.

Reasons	**Number of households**			
	Poor (N=11)	**Medium (N=41)**	**Rich (N=11)**	**Total (N=63)**
Soil, water and nutrient conservation	8	29	11	**48 (76%)**
Ease of cultivation	3	12	3	**18 (29%)**
Good for air movement	2	9	2	**13 (21%)**
Easy for weeding	2	3	2	**7 (11 %)**
Increased crop yield	1	3	1	**5 (8%)**

Note: Total number of responses exceeded total households surveyed because of multiple responses.

‘Willingness to use the technology’ was considered as a proxy-indicator for the level of future adoption of the technology, and was discussed with farmers. The number of farmers willing to use contour cultivation in the future (~89%) was higher than those willing to use downslope cultivation (~10%).

Table 5.4. Farmers’ tentative decisions about using different planting systems in the future, Household Survey, Kelang, Summer 2002

Planting system	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
Downslope planting	2	4	0	6
Contour cultivation	9	36	11	56
No definite pattern	0	1	0	1

The level of awareness, extent of testing the technology, benefit perceived from the technology and willingness to adopt contour cultivation technology by the farming households was studied the following year. The objective of this exercise was to identify the strengths and weaknesses in the technology dissemination and adoption pathways, and to understand the likelihood of adoption of the technology in future.

Contour cultivation technology was highly preferred by the farmers. All of the surveyed farmers were aware and tested the contour cultivation technology (Table 5.5). It was considered to be one of the most appropriate technologies, as 100% of the farmers surveyed benefited from the contour cultivation technology (Table 5.5). Moreover, the overwhelming majority of farmers (97%) were willing to adopt contour cultivation technology in future. This was higher than those recorded as willing to use the practice in 2002.

Table 5.5. Level of awareness, extent of testing, benefit received from and willingness for adoption of contour cultivation technology among the different wealth category of farming household in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Response	**Number of households**				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Aware	11	40	10	61	NA
Tried	11	40	10	61	NA
Benefited	11	40	10	61	NA
Willing to adopt	11	39	9	59	1.87^{NS}

Note: NS = Not Significant at P<0.05 level.

The motivation for using or not using the technology was discussed to study the farmer perceived strengths and weaknesses of the technology. The information also provided an opportunity to understand the aspects farmers would consider (i.e., farmers' criteria) for adoption/rejection of the technology. Soil and water conservation and increased production/income were the two major reasons, which motivated farmers to try contour cultivation technology (Table 5.6). It is interesting to note that 34% tried the technology with the expectation that production/income would increase (Table 5.6); however, only 8% farmers perceived this to be the outcome in the previous year (Table 5.3). In 2003, they might have had actual evidence of increased yield from contour cultivation, which they may not have had in 2002. In workshops carried out by the Project team with farmers from the catchment, conservation of soil and water was presented as the main advantage of using contour cultivation. This had clearly influenced the views of the farmers.

Table 5.6. Farmers' reasons for using the contour cultivation technology in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**
Conserve soil and water	9	34	9	52 (85%)
Increase production/income	5	12	4	21 (34%)
Ease of crop management/save labour	2	2	0	4 (7%)
Good air movement	0	4	0	4 (7%)
Conserve soil fertility	1	1	1	3 (5%)
Good light distribution	0	2	0	2 (3%)

Note: Total number of responses exceeded total households surveyed because of multiple responses.

5.3.1.2 Mulching

Most farmers (98%) reported that they did not traditionally use straw mulch. It was not an entirely new technological option for farmers, but the use of straw for mulching was almost non-existent before the Project started. The Project team attempted to re-introduce straw mulch technology, so the Project was the main source of information for this technology (Table 5.7). Polythene mulching was not a traditional technique for maize. It had been previously used for tobacco and more recently introduced for maize production. Some farmers had learnt about the technology from other sources.

Table 5.7. Source of information for the mulching technologies, Household Survey, Kelang Summer 2002.

Response	**Number of respondents**	
	Straw mulch	**Polythene mulch**
Project	48 (76%)	41 (65%)
Other farmers	1 (2%)	23 (37%)
Agricultural Department	-	8 (13%)
Tobacco purchase and sales department	-	8 (13%)

Note: Total number of responses exceeded total households surveyed because of multiple responses.

The survey revealed increasing use of mulching technology during 1999-2002 (Table 5.8). However, the increase in the use of straw mulch technology was very small, while the increase in use of polythene mulch technology was significantly greater (Table 5.9).

Table 5.8. Number of households using straw and polythene mulch during 1999-2002 in Kelang Village, Household Survey, Summer 2002.

Year	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
Straw mulch				
1999	0	0	0	0 (0%)
2000	1	0	0	1 (2%)
2001	1	1	1	3 (5%)
2002	3	7	1	11 (18%)
Polythene mulch				
1999	3	8	3	14 (22%)
2000	2	8	2	12 (19%)
2001	1	13	3	17 (27%)
2002	9	40	11	60 (95%)

Table 5.9. Comparison of extent of use of straw and polythene mulch technologies by farmers in Wang Jia catchment during 1999-2002, Household Survey, Summer 2002.

Year	**Number of households using**		χ_1^2
	Straw mulch	**Polythene mulch**	
1999	0	14	13.58***
2000	1	12	8.58**
2001	3	17	10.04**
2002	11	60	74.34***

Note: ** = Significant at P<0.01 level; *** = Significant at P<0.001 level.

The farmers' perceptions of the disadvantages/limitations of straw and polythene mulch technologies were studied by discussing the reasons for not using the technologies. Inadequate availability of straw for mulching and a higher labour requirement were the most important reasons for low uptake of straw mulching by farming households (Table 5.10). In Kelang village, most of the above-ground crop biomass (except the woody part) was used in either feeding or as bedding materials for livestock. This was ultimately recycled into the field as compost/FYM (farm yard manure), but not as mulch. It appears that short supply (low production) of straw remains an age-old problem in Kelang village, which explains why straw mulch was not a traditional practice in the area. This is a recurrent problem for farmers in subsistence farming systems in many parts of the world.

Table 5.10. Reasons for not using straw mulching technologies by the farming households in Kelang village, Household Survey, Summer 2002.

Reasons	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
Not available	6	20	6	32 (51%)
Requires more labour	8	21	2	31 (49%)
Not used traditionally	3	16	6	25 (40%)
Not economic	1	6	1	8 (13%)
Straw mulch makes weeding and other operation difficult	0	3	3	6 (10%)
Do not know about the technology, no information	1	5	0	6 (10%)
Good land – does not need straw mulching	0	2	0	2 (3%)

Note: Total number of responses exceeded total households surveyed because of multiple responses.

Most farmers used polythene mulch although they had some concerns with the technology; higher labour requirement, not used traditionally, not economic and not available were the major concerns in using polythene mulch (Table 5.11).

Table 5.11. Farmers' concerns associated with using the polythene mulching technologies by the farming households in Kelang village, Household Survey, Summer 2002.

Reasons	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
Requires more labour	7	16	4	27 (43%)
Not used traditionally	1	11	4	16 (25%)
Not economic	1	8	4	13 (21%)
Not available	1	7	2	10 (16%)
Do not know about the technology, no information	2	2	1	5 (8%)
Low economic condition	3	1	0	4 (6%)
Good land – does not need polythene mulching	1	2	1	4 (6%)

Note: Total number of responses exceeded total households surveyed because of multiple responses.

An analysis of when farmers started to use polythene mulch for maize (Table 5.12) showed that first use was strongly associated with the implementation of the Project, from 1999.

Disposal methods were also considered in the survey (Table 5.13) as leaving polythene in the cropping areas could have negative environmental impact. Most farmers threw it away, although some started to collect it to sell for recycling.

Table 5.12. First time use of polythene mulch by farmers in Kelang Village, Household Survey, Summer 2002.

Year	**Number of households**			
	Poor (N = 11)	**Medium (N = 41)**	**Rich (N = 11)**	**Total (N = 63)**
1990	0	0	1	1 (2%)
1992	0	0	1	1 (2%)
1993	0	1	0	1 (2%)
1994	0	1	0	1 (2%)
1995	0	1	0	1 (2%)
1999	2	8	2	12 (19%)
2000	1	2	0	3 (5%)
2001	0	4	1	5 (8%)
2002	8	24	6	38 (60%)

Note: Total percentage exceeded 100% because of multiple responses.

Table 5.13. Farmers' responses about the handling of polythene after use as mulch, Household Survey, Summer 2002.

Options	**Number of households**				**χ_2^2 (Wealth category)**
	Poor	**Medium**	**Rich**	**Total**	
Collect and throw away	10	25	10	45 (71%)	6.29^{*}
Collect and burn	0	5	1	6 (10%)	1.50^{NS}
Leave in the field	0	2	0	2 (3%)	1.11^{NS}
Collect and bury	0	4	0	4 (6%)	2.29^{NS}
Collect and sell	4	18	1	23 (37%)	4.53^{NS}
X_4^2 (Technology)	111.42^{***}				

Note: * = Significant at P<0.05 level; *** = Significant at P<0.001 level; NS = Not Significant at P<0.05 level. Total percentage exceeded 100% because of multiple responses.

In the 2003 survey, farmers' awareness of these mulching technologies was considered (Table 5.14). 80% were aware of straw mulching and all the farmers surveyed were aware of polythene mulching. Willingness to adopt the former was still low (21% of those surveyed).

In 2003, increases in production/income and conserving soil and water were the two major reasons given by farmers for using the polythene mulch technology (Table 5.15).

5.3.1.3 Intercropping

The 2002 survey revealed that during that season only 19% of the farmers practised a type of intercropping (Table 5.16), which appeared to be more popular among the farmers from the medium wealth category.

Table 5.14. Level of awareness, extent of testing, benefit received from and willingness for adoption of straw and polythene mulch technologies among the different wealth categories of farming households in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Technologies/ Response	**Number of households**				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Straw mulch technology					
Aware	10	29	10	49	4.78^{NS}
Tried	5	11	2	18	1.86^{NS}
Benefited	5	9	1	15	3.83^{NS}
Willing to adopt	5	7	1	13	4.93^{NS}
Polythene mulch technology					
Aware	11	40	10	61	NA
Tried	10	40	10	60	4.62^{NS}
Benefited	8	40	10	58	14.34^{***}
Willing to adopt	8	38	10	56	6.76^{*}

Note: * = Significant at P<0.05 level; *** = Significant at P<0.001 level; NS = Not Significant at P<0.05 level.

Table 5.15. Farmers' reasons for using/not using the polythene mulch technology in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor	**Medium**	**Rich**	**Total**
For using				
Increase production/income	8	29	6	43
Conserve soil and water	6	28	7	41
Easy to manage/save labour	1	5	1	7
Conserves soil fertility	0	4	2	6
Crops mature earlier	2	2	1	5
Crops grow better	1	4	0	5
For not using				
Lack of money/cannot afford	1	0	0	1

Note: Total number of responses exceeded total households surveyed because of multiple responses.

Table 5.16. Number of households practising intercropping and area under intercropping in Wang Jia catchment, Household Survey, Summer 2002.

Number of Households	**Wealth Category**				χ_2^2
	Poor	**Medium**	**Rich**	**Total**	
Total	11	41	11	63	-
Practising intercropping	1	11	0	12 (19%)	4.91^{NS}

Note: NS = Not Significant at P<0.05 level.

The 2003 survey, which considered whether intercropping had been used at all in the past, revealed that most farmers were aware of the technology and 67% had tried it in the past (Table 5.17). Over 50% felt they had benefited from using the technology and were willing to adopt it in the future, especially those in the medium wealth category.

Table 5.17. Level of awareness, extent of testing, benefit received from and willingness for adoption of intercropping technology among the different wealth categories of farming households in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Response	**Number of households**				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Aware	9	37	9	55	1.11^{NS}
Tried	6	30	5	41	3.25^{NS}
Benefited	4	28	3	35	7.66^{*}
Willing to adopt	4	26	3	33	5.65^{NS}

Note: * = Significant at P<0.05 level; NS = Not Significant at P<0.05 level.

Conflicting responses were received from the surveyed farmers while discussing the reasons for using or not using intercropping. On the one hand, increase in production was the most widely perceived reason for using intercropping technology, while on the other, adverse effects to the main crop, competition or production decreases were the most important reasons for not using the technology (Table 5.18). Further study is required to understand the underlying reasons behind these contrasting views.

Table 5.18. Farmers' reasons for using/not using the intercropping technology in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor	**Medium**	**Rich**	**Total**
For using				
Increase production/income	3	24	4	31
Good air movement	0	8	1	9
Good effect on soil by the legume crop	1	5	1	7
Better land utilisation	2	3	0	5
Conserve soil and water	0	3	0	3
Save labour	0	1	0	1
Less weed problems	0	1	0	1
For not using				
Adverse effect to main crop/ competition/ production decrease	4	5	2	11
Crop management is difficult	1	3	1	5
Lack of land	0	2	0	2
Difficult to use polythene	1	0	0	1
No advantage	0	0	1	1
Lack of labour	1	0	0	1

Note: Total number of responses exceeded total households surveyed because of multiple responses.

5.3.1.4 Tree plantations

Three tree species (sweet chestnut *Castanea mollissima* Bl., Prickly Ash *Zanthoxylum bungeanum* Maxim and Hua Shan Pine *Pinus armandii* Franch.) were planted in Wang Jia catchment. Sweet chestnut and prickly ash were planted in fields with steep slope angles (>25°), while pine was planted on the upper forest land. Farmers' responses were collected only about sweet chestnut and prickly ash trees, as the forest land did not belong to individual farmers. The Project planted trees in the fields of 31 (49%) farmers, of which sweet chestnut was planted in the fields of 25 (40%) and prickly ash in the fields of seven (11%) farmers (Table 5.19). In addition, 22 (35%) farmers planted trees on their land on their own initiatives, of which 17 (27%) planted sweet chestnut and six (10%) planted prickly ash. Irrespective of the initiatives, either from the Project or from the farmers themselves, the farmers' preference was always greater for sweet chestnut than prickly ash.

Table 5.19. Details of tree plantation in the farmers' field by the Project and farmers themselves in Wang Jia catchment, Household Survey, Summer 2002.

Details	**Number of households**	
	Planted by project	**Planted by themselves**
Total households surveyed	63	
Planted tree	**31 (49%)**	**22 (35%)**
Planted sweet chestnut	24 (38%)	16 (25%)
Planted prickly ash	6 (10%)	5 (8%)
Both	1 (2%)	1 (2%)

Planting trees on their own initiative was carried out more by the richer (rich and medium categories) compared to the poorer farming households (Table 5.20). This suggests that this technology is likely to be adopted by the richer section of the village, who can wait for the financial returns.

Table 5.20. Details of tree plantation in the farmers' field by Project and farmers themselves in Wang Jia catchment, Household Survey, Summer 2002.

Details	**Total households Surveyed**	**Number of households planted trees**			
		Trees	**sweet chestnut**	**prickly ash**	**both**
On project's initiatives					
Poor	11 (17.5%)	7	5	2	0
Medium	41 (65%)	17	12	4	1
Rich	11 (17.5%)	7	7	0	0
Total	**63**	**31 (49%)**	**24 (38%)**	**6 (10%)**	**1 (2%)**
On farmers' own initiatives					
Poor	11 (17.5%)	1	1	0	0
Medium	41 (65%)	18	12	5	1
Rich	11 (17.5%)	3	3	0	0
Total	**63**	**22 (35%)**	**16 (25%)**	**5 (8%)**	**1 (2%)**

The adoption survey in 2003 revealed that most farmers were aware of both sweet chestnut (85%) and prickly ash (84%) planting technology (Table 5.21). However, the number of farmers who tested sweet chestnut and prickly ash during the project period was variable, because the prickly ash trees were not available to farmers with land in the lower catchment, while sweet chestnut was restricted to the lower catchment. A majority of those who tried either technology felt that it was of benefit and were willing to adopt it in the future.

Table 5.21. Level of awareness, extent of testing, benefit received from and willingness for adoption of sweet chestnut and prickly ash planting technologies among the different wealth categories of farming households in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Technologies/ Response	**Number of households**				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Sweet chestnut plantation					
Aware	10	32	10	52	2.89^{NS}
Tried	8	27	7	42	0.12^{NS}
Benefited	6	25	7	38	0.54^{NS}
Willing to adopt	7	21	6	34	0.52^{NS}
Prickly ash plantation					
Aware	10	32	9	51	1.11^{NS}
Tried	3	12	6	21	3.49^{NS}
Benefited	2	8	6	16	7.06^{*}
Willing to adopt	2	7	4	13	2.49^{NS}

Note: * = Significant at P<0.05 level; NS = Not Significant at P<0.05 level.

Increasing income was the most important reason given by farmers (61%) for planting sweet chestnut (Table 5.22). This suggests that farmers in Kelang village would give a high priority to technologies that would increase household income, leading to higher adoption. Similar results were obtained for prickly ash planting, although more farmers perceived it would generate less income than annual crops (Table 5.23). In both cases, lack of land was the main reason given for not using the technologies.

Table 5.22. Farmers' reasons for using/not using the sweet chestnut planting technology in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor	**Medium**	**Rich**	**Total**
For using				
Increase income over annual crops	8	23	6	37
Available for household consumption	2	9	1	12
Conserve soil and water	1	6	2	9
Increase vegetative cover	0	1	1	2
Poor/sloping land	0	1	1	2
Save labour	0	1	1	2
For not using				
Lack of land	2	9	1	12
Lack of labour	1	0	1	2

Note: Total number of responses exceeded total households surveyed because of multiple responses.

Table 5.23. Farmers' reasons for using/not using the prickly ash planting technology in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor	**Medium**	**Rich**	**Total**
For using				
Increase income over annual crops	3	5	6	14
Conserve soil and water	0	3	2	5
Poor/sloping land	2	2	0	4
Save labour	0	1	2	3
Available for self (household)- consumption	0	1	1	2
For not using				
Lack of land	3	14	2	19
Less income than annual crops	2	7	1	10
Lack of resources (seedlings, resources)	1	3	1	5
Do not know/no information	0	3	0	3

5.3.1.5 Irrigation system

The household survey revealed low use of the irrigation facility by farmers, particularly during winter (Table 5.24), although soil moisture is particularly deficient during the winter season. The Project failed to promote widespread use of irrigation following installation of the system, as there was no change in the number of users during the entire project period. Farmers reported that the long distance between their cropping area and the irrigation pond and lack of labour were the major reasons for its low use (Table 5.25).

Table 5.24. Number of households using irrigation during 1999-2002 in Wang Jia catchment, Household Survey, Summer 2002.

Year	**Number of households**	
	Early Summer	**Following Winter**
1999	9 (14%)	2 (3%)
2000	10 (16%)	4 (6%)
2001	12 (19%)	4 (6%)
2002	9 (14%)	

Note: Number in parentheses is the percentage of surveyed households.

Table 5.25. Reasons for not using irrigation, Household Survey, Kelang, Summer 2002.

Reasons	**Number of respondents**
Far from the irrigation pond	44 (70%)
Lack of labour	14 (22%)
Land is located above the irrigation pond	6 (10%)
Irrigation insufficient	5 (8%)

Note: Number in parentheses is the percentage of surveyed households.

The use of irrigation was studied again during the 2003 survey. However, the situation remained similar to the 2002 survey. Use was again very low both in the 2002/03 winter and 2003 summer seasons (Table 5.26). Land located far from the irrigation pond was the main reason again for not using the system (Table 5.27).

Table 5.26. Number of farming households using the irrigation facility in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Year/season	**Number of households**				χ_2^2
	Poor (N = 11)	**Medium (N = 40)**	**Rich (N = 10)**	**Total (N = 61)**	
2002/03 Wheat (Winter season)	1	4	1	6	0.01^{NS}
2003 maize (Summer season)	1	5	1	7	0.12^{NS}

Note: NS = Not Significant at P<0.05.

Table 5.27. Reason for not using the irrigation facility by the farming households in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Reasons	**Number of households**			
	Poor	**Medium**	**Rich**	**Total**
Wheat (Winter season)				
Far from the irrigation pond	5	19	6	30
Did not cultivate wheat	2	4	1	7
Difficult/not convenient to use irrigation	0	4	1	5
Busy in other works	1	2	1	4
No pipe (resources)	1	2	0	3
Land is located above the pond	1	2	0	3
Lack of labour/ more labour required	1	2	0	3
Good rainfall – not required	0	2	0	2
Expect/wait for the rain	0	1	0	1
Maize (Summer season)				
Far from the irrigation pond	8	16	6	30
Busy in tobacco cultivation	2	8	1	11
Expect/wait for the rain	0	9	1	10
Difficult/not convenient to use irrigation	1	7	1	9
Good rainfall – not required	0	5	0	5
Land is located above the pond	0	2	1	3
Lack of labour/ more labour required	1	0	0	1
No tradition of irrigating maize	0	1	0	1
Not necessary	0	1	0	1

Note: Total number of responses exceeded total households surveyed because of multiple responses.

Awareness about irrigation technology among the farming households was high, but the number willing to adopt it in the future remained low (Table 5.28).

Table 5.28. Level of awareness, extent of testing, benefit received from and willingness for adoption of irrigation technology among the different wealth categories of farming households in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Response	Number of households				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Aware	11	32	8	51	2.63^{NS}
Tried	2	10	4	16	1.38^{NS}
Benefited	2	7	4	13	2.49^{NS}
Willing to adopt	2	7	3	12	0.81^{NS}

Note: NS = Not Significant at P<0.05 level.

5.3.2 Training and initial dissemination of Project technologies

The farmers in the catchment who participated in the training workshops organized by the project were surveyed in 2003 (Table 5.29). More farmers attended maize cultivation training than the wheat training, possibly indicating the higher value of the former crop, but there was no difference in attendance between wealth categories.

Table 5.29. Number of farming households who participating in training provided by the Project in Kelang Village, Yunnan Province, China, Household Survey, Summer 2003.

Area of training	Number of households				χ_2^2
	Poor (N=11)	**Medium (N=40)**	**Rich (N=10)**	**Total (N=61)**	
Improved cultivation practices of maize	10	34	8	52 (85%)	0.50^{NS}
Improved cultivation practices of wheat	9	29	6	44 (72%)	1.25^{NS}

Note: NS = Not Significant at P<0.05.

In terms of dissemination, the majority of households surveyed in 2003 received information about cropping technologies from the Project, rather than from other sources (Table 5.30).

There were significant differences (χ_6^2=77.80, P<0.001) in the number of households receiving information from the Project for different technologies. This ranged from as low as 10 (16% of surveyed farmers) in the case of straw mulch to as high as 51 (84% of surveyed farmers) in the case of contour cultivation (Table 5.30). This suggests that the efforts by the Project team varied for the dissemination of different technologies.

Table 5.30. Sources of information for different agricultural technology in Kelang Village, Yunnan Province, China, Household Survey, Summer 2003.

Technology/interventions	**Number of households**					
	SHASEA Project	**Village office**	**Tobacco Dept.**	**Other farmers**	**Traditional practice**	**Total**
Contour cultivation technology	51			3	6	60
Straw mulch technology	10			1	1	12
Polythene mulch technology	36	1	10	11	2	60
Intercropping technology	17	2		8	25	52
Sweet chestnut plantation	19	8		6	17	50
Prickly ash plantation	32	3		7	7	49
Irrigation scheme	35	3	1	6	7	52
Total	**200**	**17**	**11**	**42**	**65**	
$\mathbf{X_6^2}$	77.80^{***}					157.19^{***}

Note: *** = Significant at P<0.001.

Similarly, there was large variation in the overall availability of information for different technologies (χ_6^2=157.19, P<0.001), as only 20% of surveyed farmers received information about straw mulch technology while 98% of the surveyed farmers received information about polythene mulch and contour cultivation technologies (Table 5.30).

Overall, the vast majority of plot owners adopted some part of the Project intervention programme. Almost 92% of the surveyed farmers used one or more of the Project technologies during 2003 (Table 5.31). During 2003, YAU and Kelang village provided maize seed. In addition, there was an agreement between the village and farmers not to cultivate tobacco in the upper catchment. The real scenario of farmers' spontaneous adoption will appear in the absence of external intervention in coming years.

Table 5.31. Number of farming households using one or more of the Project technologies during 2003 in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Wealth category	**Response**		
	Yes	**No**	**Total**
Poor	10	1	11
Medium	38	2	40
Rich	8	2	10
Total	56	5	61
χ_2^2	2.41^{NS}		

Note: NS = Not Significant at P<0.05.

The wealth category of the farming households did not have any effect on the use of Project technology (χ_2^2=2.41, P=0.300) (Table 5.31). This demonstrated that a majority of farmers across the wealth categories used one or more Project technologies.

Similarly, ~ 95% of surveyed farmers considered that their households benefited from one or more of the Project technologies during 2003 (Table 5.32), irrespective of wealth category.

Table 5.32. Number of farming households benefited by the Project's research activity in Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Wealth category	**Response**		
	Yes	**No**	**Total**
Poor	11	0	11
Medium	37	2	39[#]
Rich	10	0	10
Total	58	2	60[#]
$\mathbf{X_2^2}$	1.11^{NS}		

Note: NS = Not Significant at P<0.05.
[#] - One response not available.

5.3.3 Further study of farmers' awareness, testing and willingness in relation to adoption

In the previous sections, the level of awareness of the owners of the plots used in the research about the different technologies introduced by the project have been reported. In general, the level of awareness was high for all the technologies, but willingness to use and then adopt the technology varied considerably between technologies. The highest adoption preference was shown for contour cultivation (Table 5.5) and the lowest for using the irrigation scheme (Table 5.28). In this section, the result of surveys on the awareness, previous attempt to test and willingness to adopt in future (key stages in the adoption pathway) are reported and compared for three groups of farmers:

a. 61 plot owners used in the project
b. 32 other farmers from the same catchment
c. 32 farmers from outside the catchment.

This was carried out to investigate the effectiveness of dissemination away from the centre of the Project's activities and the effect on adoption. The sample sizes varied for the three groups as it was not possible (because of time limitation) to survey more than 32 households for each of groups (b) and (c).

Awareness of the project technologies was generally high among all groups of the farmers, ranging from 82 to 100% except for straw mulch (58%) (Table 5.33). The level of awareness among farmers for different technologies was statistically significant (χ_6^2=91.36, P<0.001) (Table 5.34). The difference among different category farmers (i.e., plot owner, farmers within the catchment and outside the catchment) was statistically significant for the awareness of straw mulch (χ_2^2=32.84, P<0.001) and contour cultivation (χ_2^2=18.02, P<0.001) technologies. Plot owners and other farmers from within the catchment were more aware about these technologies than farmers from outside the catchment (Table 5.33).

Extent of testing of different technologies by farmers was statistically significant (χ_6^2=242.21, P<0.001) (Table 5.34). This is evident from the wide gap in the number of farmers testing different technologies, which ranged from 21 - 92%. Polythene mulch (92%), contour cultivation (85%), sweet chestnut planting (73%) and intercropping (65%) technologies were tested by >50% of the surveyed farmers, while farmers were found reluctant to test straw mulch technology (21%). The statistical difference among the three different groups for the number of farmers testing the technologies was significant for polythene mulch, contour cultivation and sweet chestnut planting technologies. The number of farmers within the catchment was significantly lower (72%) than farmers from outside the catchment (100%) and plot owners (98%) for the testing of polythene mulch technology (χ_2^2=23.75, P<0.001) (Table 5.33), while the number of plot owners (100%) testing contour cultivation was significantly higher than farmers from within (78%) and outside (63%) the catchment (χ_2^2=24.39, P<0.001). However, the number of farmers testing sweet chestnut planting technology was significantly more from outside the catchment (91%) compared to plot owners (69%) and farmers from within the catchment (63%) (χ_2^2=7.33, P<0.05). Similarly, significantly more farmers from outside the catchment (59%) tested an irrigation system than farmers from within the catchment (34%) and plot owners (26%) (χ_2^2=10.02, P<0.01).

Over all groups, farmers' willingness to adopt the Project technologies ranged from as low as 16% for straw mulch to as high as 89% for polythene mulch technology (Table 5.33) and the difference between technologies was statistically significant (χ_6^2=1236.62, P<0.001, Table 5.34). The difference between plot owners, farmers from within and outside the catchment was also statistically significant in the case of polythene mulch (χ_2^2=13.81, P<0.01), contour cultivation (χ_2^2=20.73, P<0.001) and irrigation (χ_2^2=9.31, P<0.01) technologies (Table 5.33). As found for testing and equally surprisingly, farmers within the catchment were less willing to adopt polythene mulch (72%) compared to farmers from outside the catchment (100%).

Table 5.33. Level of awareness, extent of testing and willingness for adoption of project technologies among the farming households from three different categories in and around Wang Jia catchment, Yunnan Province, China, Household Survey, Summer 2003.

Technology/ Interventions	**Number of households**				χ_2^2
	Plot owner (N=61)#	**Within catchment (N=32)**	**Outside catchment (N=32)**	**Total (N=125)**	
a. Contour cultivation technology					
Aware	61	28	23	112	18.02^{***}
Tried	61	25	20	106	24.39^{***}
Willing to adopt	59	25	19	103	20.73^{***}
b. Straw mulch technology					
Aware	49	18	6	73	32.84^{***}
Tried	18	4	4	26	5.48^{NS}
Willing to adopt	13	4	3	20	2.62^{NS}
c. Polythene mulch technology					
Aware	61	32	32	125	NA
Tried	60	23	32	115	23.75^{***}
Willing to adopt	56	23	32	111	13.81^{**}
d. Intercropping technology					
Aware	55	29	28	112	0.21^{NS}
Tried	41	20	20	81	0.30^{NS}
Willing to adopt	33	15	20	68	1.58^{NS}
e. Sweet chestnut plantation					
Aware	52	28	32	112	5.11^{NS}
Tried	42	20	29	91	7.33^{*}
Willing to adopt	34	19	25	78	4.65^{NS}
f. Prickly ash plantation					
Aware	51	28	24	103	1.84^{NS}
Tried	21	6	12	39	3.20^{NS}
Willing to adopt	13	5	10	28	2.33^{NS}
g. Irrigation scheme					
Aware	51	26	26	103	0.12^{NS}
Tried	16	11	19	46	10.02^{**}
Willing to adopt	12	9	16	37	9.31^{**}

Note: * = Significant at P<0.05; ** = Significant at P<0.01; *** = Significant at P<0.001; NS = Not Significant at P<0.05; NA = Not Applicable.
Data recovered from Tables 5.5, 5.14, 5.17, 5.21 and 5.28.

Table 5.34. Difference among Project technologies for level of awareness, extent of testing and willing to use in future by the farmers, Household Survey, Kelang village, Summer 2003.

Category of farmers	**Stage of adoption**	X_6^2
All groups (Table 5.33)	Aware	91.36^{***}
	Tested	242.21^{***}
	Willing to adopt	1236.62^{***}

Note: *** = Significant at P<0.001.

5.4 Discussion

The household surveys carried out in 2002 and 2003 have identified marked differences in the perceptions of the farmers about the various technologies introduced to the catchment by the Project team.

5.4.1 Cultivation methods

Contour cultivation was one of the most appropriate technologies for Wang Jia. In addition to the overwhelming preference of farmers, this technology has far-reaching favourable effects on the environment and farming system sustainability of sloping upland areas (Milne, 2001; Barton *et al.*, 2004). The extent of benefit will depend on future adoption/adaptation of the technology by farmers from not only Wang Jia but from other similar areas. Downslope cultivation is a traditional practice and it is widely used in Yunnan Province. Considering the popularity of downslope cultivation in Yunnan Province, the wide adoption of contour cultivation will be possible only after considerable efforts for technology dissemination. It means despite the achievement in developing such useful technology, the real benefits depend on future course of action to disseminate such successful technologies (Tang Ya, 1999). The positive views of farmers outside the catchment suggest that the adoption potential for contour cultivation is high.

5.4.2 Mulching

Farmers liked the polythene mulch technology as 95% of the farmers felt they received benefit from using polythene mulch overall. Fewer poor farmers were willing to adopt the technology for maize, preferring to use polythene for high value crops only, because of the cost involved in purchasing the polythene. Although only 9% of farmers who did not wish to use polythene gave cost as the reason, limited use of polythene mulch by poor category farmers can be expected, unless an economic return is guaranteed. It should be noted that the high adoption achieved was strongly influenced by Government subsidy, amounting to approximately 50% of the cost to the farmer (Wu Bo Zhi, 2002, *pers. comm.*). How farmers will respond if the subsidy is lifted would be an aspect for further study.

The surveys revealed that farmers were not generally aware of the pollution caused by polythene not being collected and disposed of properly after use. The cumulative effects could be serious in a situation where polythene is popular and use is very high. Only 37% of farmers recycled polythene after use (Table 5.13). The practice of the remaining farmers would be environmentally hazardous in the longer term. In China, pollution caused by used polythene is known as ‘white pollution’ (Huang BiZhi, 2002, *pers. comm.;* Wu Bo Zhi, 2002, *pers. comm.;* Li YongMei, 2004) and the Chinese Government is committed to reduce the problem of white pollution (BBC, 1997; Shenzhen Daily, 2001; China Internet Information Center, 2002). Project staff advised farmers to collect and remove the polythene from the fields after its use, but only one-third of the farmers followed this advice. This indicates that insufficient efforts were made to increase farmers’ awareness of the hazardous effects of polythene in order to motivate them to collect and dispose of polythene from farmland. This aspect needs to be considered when designing programmes for the further dissemination of SHASEA results.

The attempt to achieve adoption of straw mulching for maize was relatively unsuccessful, largely because of low availability of the material, or the preference to use any available straw for other purposes. The original intention of the Project team was to increase the availability of straw by improving the winter crop of wheat. This did not materialise largely because the farmers were unwilling to use the irrigation system to improve soil water availability – the main cause of poor wheat yields in the winter season.

5.4.3 Intercropping

Intercropping was not a new practice for the farmers in Wang Jia catchment; they had been practicing intercropping in their own traditional way. The Project attempted to develop improved intercropping technologies for use in Wang Jia catchment. Farmers appreciated the potential benefit of the intercropping system as they identified ‘increasing crop production/income’ as the most important advantage of the system. Despite this, however, very few farming households actually used the intercropping technology evaluated by the Project. This could be because it was not considered to be suitable for existing farming systems, as some farmers perversely gave ‘adverse effects to the main crop/competition/production decrease’ as an important reason for not trying the technology. This has been reported in other adoption studies (Fujisaka, 1991; Ruaysoongnern, 1999; Tang Ya, 1999). The poor performance of the companion crop (soybean) in Project-managed plot experiments (Wang ShuHui, 2003) might have deterred farmers from using this particular model of intercropping technology.

5.4.4 Tree planting

Tree planting technology, particularly sweet chestnut, was a viable income-generating option for farmers and many preferred this technology. The adoption of trees is a long-term investment, so poor farmers often give priority to annual crops when deciding on land-use, in order to meet annual food requirements (Pretty, 1995; Tang Ya, 1999). 'Lack of land' should be understood as 'lack of extra land' (land which the farmer can use for long-term investment and wait some years for the income).

Agro-forestry systems involve growing a combination of woody perennial species and agricultural crops in the same place and at the same time (Bridges and Oldeman, 2001). The SHASEA Project developed its tree planting technology within this agro-forestry concept. This could meet farmers' needs for both staple crops and cash income and improve environmental conditions in the catchment. Field observations revealed that few of the farmers were following the scientific recommendations from the Project, particularly maintaining the spacing between plants, as tree densities in the farmers' field were found to be quite variable. This neglected:

a. the optimum density of trees and crops for maximum combined output;
b. the environmental impact of trees at different densities, i.e. the minimum tree density required for favourable environmental effects and the optimum density for best environmental effects.

This resulted in large income differences from tree or tree/crop mixtures among different farmers. This suggests that the role of tree planting technology to improve both the environment and household income was not fully understood. This is an area for future work.

5.4.5 Irrigation

Lack of sufficient soil moisture during winter, spring and early summer is one of the limiting factors for crop production in South China (SHASEA, 2000). Irrigation provides an opportunity to plant before the rains have started, thus lengthening the cropping season. The Provincial Government of Yunnan has been trying to increase the irrigation area as a measure to improve crop productivity (Huang BiZhi, 2001). In this context, village leaders asked the Project team to support the establishment of an irrigation system in the catchment. Consequently an irrigation system, with 5 ponds and pipe links between the ponds, was constructed in the early part of the Project by a village work team (SHASEA, 2000). A researcher-managed plot experiment in the catchment revealed that irrigation increased maize yield by ~40-60% in a season when the spring rains were late (Huang BiZhi, 2001). There was, therefore, a clear need for an irrigation system and an apparent commitment by the local community to use irrigation. Despite this, many farmers did not use irrigation after the system was constructed. The possible reasons could be:

- More labour is required for irrigation, which increases the production costs. Perhaps farmers considered that the increased income due to irrigation would not justify the higher input. Farmers mentioned reasons like ‘lack of labour’ or ‘busy in other activities’ to express their concern about the economic return from the extra resources invested in irrigating the crops. The responses also revealed the farmers’ resource allocation strategy. They gave priority to more profitable crops, for example 18% of farmers said they were busy growing tobacco, which prevented them from irrigating maize (Table 5.27).
- Most farmers have small land holdings. Therefore they would get only a small increase in their total income from the investment in irrigation. Farmers might be less interested in carrying out extra work (for irrigation) for the small increase in their total income.
- The winter crop of wheat, for which the irrigation is particularly necessary, is not profitable.
- The Project focussed on improving maize-based cropping systems in the summer and wheat-based cropping systems in the winter. Perhaps the farmers’ real intention was to use irrigation for higher value crops after the end of the Project, rather than for maize and wheat.

Further investigations would be necessary to arrive at firm conclusions on this issue.

5.4.6 Training and dissemination

Training and dissemination activities were planned primarily for farmers within the Project area, so each household within the catchment received an opportunity to participate in these processes. There were no gender- or user-differentiated training and dissemination activities, so female participation in these activities was voluntary. Wider dissemination of the project outcome was intended to be achieved by: a) distributing the reports; b) developing the website; c) holding meetings with local farmers and township leaders; d) holding regional conferences, open days at the catchment and other promotions; e) production of training materials; f) production of long term cropping plans for the locality; g) production of papers for international conferences and refereed journals (SHASEA, 1997). The dissemination of Project outcomes to the scientific community was achieved successfully, but efforts for wider dissemination to farming communities were much less successful. Some of the activities aimed at disseminating Project outcomes to farming communities were largely ineffective; for example: production of training materials was not achieved; meetings with local farmers, particularly outside the catchment, were insufficient; participation of farmers from outside the catchment during the open days was very low.

An additional ‘Accompanying Measures’ programme was implemented at the end of the Project to: a) introduce the research findings of the SHASEA Project to potential users, to assist dissemination of research results from the project; b) promote the practical applications of the research for improving the productivity and sustainability of cropping systems on fragile highland slopes in S. E. Asia in an environmentally-friendly way (SHASEA, 2002b)b). However this again appeared to be more effective in improving the dissemination to the scientific community than the local farming communities outside the catchment.

Availability of information is the most important pre-requisite to adoption by farming households (Cruz, 1997; Muhammad *et al.*, 2001). The extent of testing the technologies by farmers and willingness to adopt them in the future were influenced by the availability of information (Sidibe, 2005). In this study, the number of farmers testing the technology accords with the number of farmers receiving information about the technology (Table 5.33). This then influenced the willingness of farmers to adopt the technology. This emphasizes the importance of effective dissemination for any agricultural development programme.

Farmer-to-farmer dissemination also plays a significant role in the extension of agricultural technologies (Subedi and Garforth, 1996; Garforth *et al.*, 2003). In Kelang village, farmers received information about agricultural technology from other more innovative farmers in the village (Table 5.30). It is known that farmers can act as extension workers themselves, as they can relate more quickly with their fellow farmers and technology transfer proceeds more easily (Maglinao, 1996). In such cases, they could be the permanent source of information for other recipient farmers, as farmers feel more comfortable to interact with someone from their own community than any external experts/technicians. Identification of such information-providing farmers and utilising them in the dissemination (extension and training) activities of project outcome would increase farmers’ acceptance of the project technologies.

5.4.7 Adoption study

Dissemination activities for farmers outside the Project area were very limited and relatively ineffective, so any awareness, testing, and willingness to adopt Project technologies by farmers outside the catchment was considered to be a ‘spill over’ effect, possibly by farmer-to-farmer dissemination. The adoption study investigated this phenomenon, as well as adoption inside the catchment.

Statistical analysis generally showed few significant differences between farmers from different wealth categories in the level of awareness, extent of testing, benefit received and willingness to use the Project technologies in the future. By contrast, the differences between Project technologies in terms of the level of awareness, extent of testing and willingness to use was significant. Possible reasons include:

- the effort was not same for testing, evaluating and disseminating all Project technologies. Some technologies received more attention than others. For example, grass strip technology did not receive much attention during the Project and awareness was low.
- some technologies could not be extended to all areas and farmers due to natural circumstances. For example, sweet chestnut was not planted in the upper catchment and irrigation was not available on the steeper slopes above the irrigation ponds.
- inputs required for testing and adoption of the technology were not always available. For example, farmers could articulate the advantages of straw mulch, but straw remained a scarce resource. Therefore the gap between the number of farmers who were aware and who were willing to use the technology in future appeared to be large.

The results of the comparisons between plot owners, farmers in the catchment and farmers outside the catchment, where there were significant differences, were both interesting and surprising. The results for mulch technology are a good example. The level of Project effort influenced the level of testing and future adoption of the technology by farmers in the catchment. The Project team worked closely with plot owners, who received various supports from the Project, in the form of training/advice, materials (inputs such as polythene, fertilisers, seed and seedlings) and cash (labour subsidy and compensation). Project support to other farmers within the catchment was limited and provided only during the last year of the Project. This could account for a greater number of plot owners testing and being willing to adopt the technology. The Project did not work outside the catchment, so farmers outside Wang Jia did not receive any kind of Project support. However, all the farmers surveyed from outside the catchment reported that they had tested and were willing to adopt polythene mulch technology. This looks contradictory to the earlier conclusion, but field visits and additional discussions with farmers and key informants revealed that every farmer outside the catchment grew tobacco, using polythene mulch. Tobacco cultivation was restricted in the catchment and maize cultivation was encouraged. So the response of the farmers outside the catchment was probably directed more towards the use of polythene mulch for tobacco.

The responses on contour cultivation may also have been influenced by crop considerations. Plot owners showed the highest level of testing and willingness to adopt the technology followed by farmers from within the catchment. However, unlike polythene mulch, more farmers were willing to adopt contour cultivation technology towards the centre of its origin (introduction) as 97% of plot owners, 78% of farmers within the catchment and only 59% of farmers from outside the catchment were willing to adopt contour cultivation. Field visits and discussions with key informants revealed that farmers generally use downslope cultivation for tobacco production. Tobacco is more susceptible to water logging conditions compared to maize. The gap between the ridges in downslope cultivation creates small channels along the slope. These small channels serve as drainage channels and help to drain excess water quickly during torrential monsoon rains, preventing water stagnation in the field. Moreover, downslope cultivation is the farmers' traditional practice. Farmers are familiar with this age-old practice, which they prefer to use, unless there is external intervention in the form of education and extension.

The extent of testing and future adoption of irrigation technology was also influenced by the type of crop grown by farmers. Irrigation is more important for tobacco than maize. Moreover, farmers reported that tobacco offers a higher return for the additional resources invested in irrigating than maize. That is why farmers from outside the Project area were more interested in testing and adopting the irrigation technology than plot owners and farmers within the catchment.

5.5 Conclusions

1. Contour cultivation was an appropriate and effective technology for the Wang Jia catchment. It was one of those most preferred by the farmers. Consequently it is likely to be adopted in wider areas. Further efforts in dissemination would help to replace the traditional downslope cultivation practice, which is more damaging to soil conservation.

2. Polythene mulch is one of the other preferred technologies, although wider adoption is more likely for higher value crops. More effective training methods are required to increase farmers' awareness of, and motivate them into practising, environmentally friendly methods of collection and disposal of used polythene.

3. Low uptake of straw mulching was due mainly to the low availability of straw. Any future promotion of straw mulch technology would have to identify more effective ways of increasing straw production.

4. Farmers in Wang Jia catchment have practiced traditional methods of intercropping. The introduced technology was not attractive to the farmers and uptake was low.

5. Planting sweet chestnuts in the lower part of the catchment and prickly ash in the upper part were viable income-generating options for farmers. Although farmers liked these practices, wide adoption by smallholders is unlikely, as poor farmers still give a high priority to the production of annual crops.

6. There was an identified need for irrigation, as the local stakeholders were willing to install a system and scientific evaluation demonstrated the benefits of using irrigation. However, many farmers still did not use the system. Possible reasons could be:
   - The cost of irrigation (especially labour costs) was more than the anticipated benefit from increased production.
   - The winter crops are not profitable, as grown in Wang Jia.
   - Farmers may have been planning to use irrigation for growing high-value crops after the Project was over.

7. Training and dissemination activities were conducted primarily within the Project area and focused on research activities. Wider dissemination of project technologies to farming communities was not achieved.

8. The extent of technology testing by farmers and their willingness to adopt effective practices in the future was influenced by the availability of information, which is an important pre-requisite for future adoption/adaptation. Therefore there is need for further dissemination work in order to achieve wider adoption/adaptation of the SHASEA Project technologies.

9. Farmer-to-farmer dissemination also played a significant role in the extension of agricultural technologies in Kelang village. Identification of information-providing

farmers and involving them in the dissemination (extension and training) activities would increase other farmers' awareness and acceptance of Project technologies.

10. Perceptions about some of the technologies were influenced by the type of existing crop grown. For example, both polythene mulch and irrigation are more widely used for tobacco than for maize, because of the higher return from tobacco compared to maize and were more likely to be adopted by tobacco-growing farmers outside the catchment.

Chapter 6: Participatory Rural Appraisal (PRA)

6.1 Introduction

SHASEA Project activities were expected to have effects broadly at two levels, viz. household and community/catchment levels. The effects on the household would have been increased yields and higher gross income, but also higher labour requirements and input costs. The effects on the catchment (and therefore the community) would have been decreases in soil and water losses and decreases in landslides and localised flooding, due to the engineering works (construction of checkdams), tree plantation and the widespread use of contour cultivation. However, the magnitude of the effects at household level was likely to vary among households due to variations in economic status, input use and labour availability, considered in Chapter 5 using a survey approach with one-to-one interviews. In this chapter, the use of participatory group approaches for the evaluation of the SHASEA Project activities and outcomes at a broader (community/catchment) level are considered. PRA methods, such as group discussions, transect walks, farmers' workshops and field observations, were conducted with the active participation of farmers. The effects of the Project interventions on environmental conditions in the catchment and the socio-economic conditions of farmers are discussed.

Participatory Rural Appraisal (PRA) is a collective name for approaches and methods to enable rural people to share, enhance and analyse their knowledge of life and conditions, to plan and to act collectively (Chambers, 1994; Stocking and Murnaghan, 2001). PRA tools typically involve local people in the identification of problems or planning of research/development activities, the assessment of impacts on their livelihoods and selection of the most appropriate means of addressing the problem(s) identified (Stocking and Murnaghan, 2001). PRA is now widely used in many parts of the world (Chambers, 1995; Edward, 1995; Guijt and Cornwall, 1995). The methods can create a feeling of achievement amongst participants, which, in turn, helps to enhance self-confidence and self-esteem (Koning, 1995). PRA exercises are more relaxing to both participants and facilitators and produce more reliable information (Turkelboom, 1999). The following PRA tools were used in this study:

Wealth categorisation

Participatory wealth categorisation involves grouping or ranking households according to well-being by a group of representative farmers including those considered to be the poorest or worst off (Pretty and Vodouhe, 1997; Chambers, 2004). Farmers of differing wealth have different problems and needs and varying ability to adopt/adapt proposed technologies and development interventions (Tung and Balina, 1993). It is also helpful to examine each category for differences in access and resource management (Carter *et al.*, 1993). Thus, in order to study the perceptions of different wealth categories concerning Project technologies and their future adoption, a wealth categorisation exercise was undertaken.

Group discussion

This is a discussion with the group of target people generally involving participants from different sectors (i.e. wealth categories, genders and occupations). Group composition (focused or mixed group) can be varied depending on the nature of the study.

Personal interview

Interviews with members of the target group are conducted to gain understanding of their responses at personal or household level.

Key informant survey

Key informants are the community members who are particularly qualified to provide information about local conditions (Stocking and Murnaghan, 2001).

Ranking

The use of ranking tools generally has been described as a 'playing analytical tool' (Stocking and Murnaghan, 2001). Ranking is used to study local peoples' categories, criteria, choices and priorities (Pretty and Vodouhe, 1997). Farmers use their own criteria to compare the objects under study, for example, Project technologies or development interventions. So, farmers' ranking could be different to researchers' ranking. Moreover, the ranking of one stratum of farmers could be different to that of other strata.

Time lines and local histories

Time lines are used to record change over time (Stocking and Murnaghan, 2001). Historical analyses have been found to be a good 'icebreaker' for field exercises and include detailed accounts of the past, of how things have changed, particularly focusing on relationships and trends (Pretty and Vodouhe, 1997).

Transect walks and farmers' workshop

These are systematic walks with key informants through areas of interest, observing, asking, listening, looking and seeking problems and solutions (Pretty and Vodouhe, 1997). Depending on the purpose, transect walks can also be conducted by a mixed group of local people and visiting professionals (Mahiri, 1998).

Local indicators

These are criteria or bases used by local people to identify or compare changes. This provides the basis for participatory monitoring and evaluation (Chambers, 2004).

Triangulation

This is a technique used to check information gained from different sources and to investigate further reasons behind inconsistencies (Stocking and Murnaghan, 2001). Triangulation seeks multiple perspectives through different methods, analyses, entities sampled, locations, points in a distribution, sources of information, and/or disciplinary perspectives, leading to cross-checking, successive approximation and/or appreciation of ranges of variance (Chambers, 1997). Triangulation entails using more than one method or source of data in the study of social phenomena so that findings may be cross-checked (Ackroyd and Hughes, 1981; Vogt, 1999; Bryman, 2001; Conroy, 2002).

6.2 Methodology

6.2.1. PRA – Wealth categorisation exercise

A participatory wealth categorisation exercise was carried out for the purpose of conducting separate PRA exercises with different wealth strata in the village. The exercise was conducted on 4 August 2002. All farmers who use land in the catchment were to be categorised in to rich, medium and poor categories. A list of names of household heads was obtained from the Township Office. Fifteen farmers from Kelang village participated in the exercise. The participants developed criteria before categorisation (Section 6.3.1). After that, participating farmers categorised each household into one of the three wealth categories, based on the criteria developed by the participants themselves.

6.2.2. PRA – Group discussion exercise

6.2.2.1 Preparation

A checklist was prepared for this group exercise. All questions in the checklist were translated prior to the exercise. The checklist was discussed in a meeting with other Project scientists, including the survey team (Annex 6.1). Minor changes in the checklist were made following the discussion. The facilitators were then given training on PRA techniques (a brief training note was prepared for this purpose) following a pilot PRA exercise, as none of the facilitators had previous PRA experience.

6.2.2.2 Execution

Undergraduate students and assistant lecturers from YAU helped in facilitating the group exercise (Annex 6.1). Four different group discussion exercises were conducted; one exercise with each of the wealth categories (rich, medium and poor) and a fourth one with a mixed group of all three wealth categories. Achieving the genuine participation of farmers in the group discussion was very important (Plate 6.1). This issue was discussed in detail with a member of the Village Committee who assisted in managing and organising the exercise. Farmers were selected for the group discussion, who were primarily involved in agriculture for their livelihood, were more innovative and could provide more useful information. The criteria for the selection of farmers were discussed with village leaders. Then the lists of participants were prepared based on the suggestions of village leaders. An attempt was made to involve at least 50% female participants in the group discussions. In the case of unavailability of female participants, the spaces in a group were filled by available male participants.

Plate 6.1 PRA exercise (group discussion) with farmers of Wang Jia catchment in Yunnan Province, China. (Source: Author)

A total of 63 farmers participated in group discussions during 2002, of which 43% were female (Table 6.1). Similarly, 60 farmers participated in 2003, of which 25% were female.

Table 6.1 Number of participants by gender and wealth categories, Group discussion exercise, Kelang village, Yunnan, China, Summer 2002.

Gender	**Poor**	**Medium**	**Rich**	**Mixed**				**Total**
				Poor	**Medium**	**Rich**	**Total**	
2002								
Male	10	8	6	2	5	5	12	36
Female	5	6	6	3	5	2	10	27
Total	15	14	12	5	10	7	22	63
2003								
Male	10	14	8	4	4	5	13	45
Female	4	7	1	0	3	0	3	15
Total	14	21	9	4	7	5	16	60

6.2.2.3 Post-discussion activity

The discussion was conducted in Chinese and all questions and responses written in Chinese. Farmers' responses were translated on the same evening in order to avoid any confusion. The responses from different groups were pooled to study the disparity between different wealth categories.

6.2.3. PRA - Farmers' workshop

The objective of this workshop was to study farmers' perceptions of the Project's effectiveness in improving environmental conditions in the catchment. This was done by examining and comparing the environmental situation of Wang Jia catchment and the Lai Zi catchment (adjacent catchment). Sixteen farmers participated in this activity, of which 19% were female (Table 6.2).

Table 6.2 Number of participants by gender and wealth categories, Farmers Workshop, Kelang village, Yunnan, China, Summer 2002.

Gender	**Number of participants**			
	Poor	**Medium**	**Rich**	**Total**
Male	3	4	6	**13**
Female	1	1	1	**3**
Total	**4**	**5**	**7**	**16**

This activity was completed in three major stages:

1. Development of Criteria
2. Examination of the catchments
3. Comparison of the catchments

6.2.3.1 Development of criteria

Farmers were first requested to develop their criteria for the examination, evaluation and comparison of the catchments (Section 6.3.3).

6.2.3.2 Examination of the catchments

After developing the criteria, farmers were requested to examine and compare the environmental conditions of the two catchments based on these criteria. A transect walk was organised so that farmers had the opportunity to closely examine both catchments. The walk was initiated from the bottom to the top of the Project catchment, from where participants crossed the stream gorge on the east side of Wang Jia catchment and reached the top of Lai Zi catchment. Farmers examined this catchment while climbing down towards the bottom.

6.2.3.3 Comparison of the catchments

A group session was organised at the bottom of the second catchment, to complete the evaluation exercise. The conditions of the two catchments were described, evaluated and compared based on rigorous discussion of each criterion. An overall comparison was carried out at the end of the session.

6.3 Results

6.3.1 Wealth categorisation

A set of criteria was developed by participating farmers to categorise the wealth classes of the 152 households of Wang Jia catchment. Farmers identified the three distinct wealth classes in the village, considering seven different indicators for wealth categorisation (Table 6.3). Threshold values were based on the judgement of the participating farmers' group. Developing criteria appeared to be very difficult due to lingering debate among the farmers, although very interesting ideas evolved. For example, the farmers considered that total family income does not make sense as a criterion for wealth categorisation, as the living condition of a big family with high income could be poor compared to a family with lower income but small family size. So income should be determined on a per head basis. Similarly, a large house may not be an indicator for wealth if the house was crowded with many family members. Therefore, house area available per person should be the basis for categorisation.

The farmers' perceived wealth categories of the farming households are presented in Table 6.4. Out of 152 farming households in Wang Jia catchment, 17 (11.2%) were categorised as poor, 111 (73%) as medium, and 24 (15.8%) as rich. The higher percentage in the medium wealth category suggests low economic disparity among the farmers.

Table 6.3 Farmers' criteria for wealth categorisation, Kelang village, Yunnan, China, 2002.

Criteria	**Rich**	**Medium**	**Poor**
Income	More than 3000 Yuan/person/year	More than 800-3000 Yuan/person/year	Less than 800 Yuan/person/year
Transportation possession	Possess bus or truck	Possess tractor or horse carriage	No possession of private transport
Type of job	Farming minor activity. Major work outside the village with higher paid job	Farming and some part time work	Just farming, but with poor management
Off-farm business	Running big enterprise in city or county	Running small enterprise operating in a small town like Kelang	No business enterprise in city or village
Condition of house	40 m^2 house area/person, attached toilet/bathroom, good brick wall, concrete roof	30 m^2 house area/person, good brick wall, tile roof	Less than 20 m^2 house area/person, poor quality brick wall, tile roof
Land type	Land productivity = ~ 600 kg/mu, using improved technologies and very good crop management	Land productivity = ~500 kg/mu, using improved technologies	Land productivity = ~300 kg/mu, not using improved technologies and poor crop management
Livestock possession	At least 1 cattle and 4 pigs	At least 4 pigs	1 pig

Note: 15 mu = 1hectare.

Table 6.4 Wealth categories of the farming households in Wang Jia catchment, Yunnan, China, Summer 2002.

Wealth category	**Number of Households**	**Percentage of households**
Poor	17	11.2
Medium	111	73.0
Rich	24	15.8
Total	152	100

6.3.2 Group discussion

An INCOPLAST (Integrated Contour Cultivation, Polythene and Straw Mulch Treatment) system was evaluated in Wang Jia catchment by the SHASEA Project and extended to farmers in Kelang village via a training workshop. This system was developed by combining the best of the techniques identified during earlier plot trials and was designed to improve yield by the addition of polythene mulch and to conserve soil, water and nutrients by the use of contour cultivation and straw mulch (Li YongMei, 2004). In the field, irrigation water is applied prior to monsoon rains, thereby maximising yield by promoting the early establishment of crop growth.

Ridge morphology is shaped to route water towards the maize root beneath the polythene mulch. Experiments have proved that soil bulk densities beneath the polythene mulch remain low throughout the growing season, thus promoting easier root penetration, higher infiltration and lower runoff rates (Fullen *et al.*, 2001). However, a complete transfer of the INCOPLAST system from experimental plots to the farmers' fields was not observed. Farmers did not perceive the INCOPLAST system in its totality, rather farmers were found to consider the components of the technology for their evaluation and adoption/adaptation. Therefore farmers' perceptions about the component technologies and initial adoption/adaptation of those technologies by farmers have been studied.

6.3.2.1 Cultivation method

Farmers' perceptions about temporal change in cultivation methods were studied in the PRA survey, during which the percentage area under different cultivation methods was discussed. The information about the past and present was based on their experience, while farmers' responses about the future were based on their expectations, considering past and present trends. The study showed an increase in the area under contour cultivation and a decrease in the area under downslope cultivation (Table 6.5).

Table 6.5. Percentage area under different cultivation practices in Wang Jia catchment and adjacent area, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Wealth Category	**Cultivation methods**	**% Area under different cultivation practice**		
		4 yrs ago (1998)	**Now (2002)**	**After 3 yrs (2005)#**
Poor	Downslope cultivation	95% (100%)	0% (20%)	0% (0%)
	Contour cultivation	5% (0%)	100% (80%)	100% (100%)
	No definite pattern	0% (0%)	0% (0%)	0% (0%)
Medium	Downslope cultivation	50% (50%)	0% (10%)	0% (0%)
	Contour cultivation	50% (50%)	100% (90%)	100% (100%)
	No definite pattern	0% (0%)	0% (0%)	0% (0%)
Rich	Downslope cultivation	80% (NA)	0% (NA)	0% (NA)
	Contour cultivation	20% (NA)	100% (NA)	100% (NA)
	No definite pattern	0% (NA)	0% (NA)	0% (NA)
Mixed	Downslope cultivation	60% (50%)	2% (20%)	0% (10%)
	Contour cultivation	30% (50%)	98% (80%)	100% (90%)
	No definite pattern	10% (0%)	0% (0%)	0% (0%)

# = Farmers' expectation based on present trends.
NA = Not available.
Figures in parentheses are information about areas outside the catchment.

Before the Project intervention (in 1998), ~71% (50-95%) of the area was under downslope cultivation practice, while ~26% (5-50%) was under contour cultivation. These figures changed dramatically at the end of the Project (in 2002) when only a small proportion of the area (<1%) was under downslope cultivation practice and a large proportion (~100%) was under contour cultivation. Farmers expected that contour cultivation would be used in the entire area in future. There was a large variation in the estimate from different wealth categories for the area under different cultivations in the past (1998), while the responses for present and future were very similar.

Downslope cultivation and 'no definite pattern' (i.e., cultivation without following any particular system, neither downslope nor contour) were the traditional cultivation practices in the areas that were being replaced by contour cultivation (Table 6.6). Cultivation practice with no definite pattern almost did not exist four years previously (Table 6.5), but surprisingly all participants of poor and medium groups and 58% of the rich group mentioned that 'no definite pattern' was the traditional cultivation practice. The participants might have considered the farmers' practice of the period well before the modernisation of agricultural systems in China to describe the traditional practice, which obviously was different from farmers' practice in the recent past, i.e. four years previously. However, this remains an anomaly in the farmers' response.

Table 6.6. Traditional summer cultivation method in and around Wang Jia catchment, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Response	**Number of respondents**			
	Poor	**Medium**	**Rich**	**Mixed**
Downslope cultivation			5 (42%)	22 (100%)
Contour cultivation				
No definite pattern	14 (100%)	15 (100%)	7 (58%)	

The advantages and disadvantages of different cultivation practices were discussed. Easy for earthing-up, easy use of polythene, weed control, tillage, and easy drainage (or no water stagnation) were perceived to be the advantages of downslope cultivation practice (Table 6.7). Increased losses of soil and water (or difficult to conserve soil and water), decreased crop production (or difficult to increase crop production) and decreased water availability to crops were the major disadvantages of downslope cultivation.

Table 6.7. Farmers' perceptions about the advantages and disadvantages of the downslope cultivation method, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Advantages/Disadvantages	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Advantages				
Easy to earth-up	1	1	1	3
Easy to cover polythene in sloping land	2	3		1
Easy for weed control		2		2
Easy to till		4	2	4
Easy to drain water (no water stagnation problem)	3			5
Facilitates good air movement in the crop land	5			
Less labour required for planting				6
Easy for inter cropping				7
Disadvantages				
Increased losses of soil and water (difficult to conserve soil and water)	1	2	1	1
Decreased crop production (difficult to increase production)		1		2
Decreased water availability to crop	2			
Soil fertility losses		3	2	3
More lodging			3	4
Wind movement in the crop land is poor				5
More labour required for harvest				6

Similarly, farmers perceived soil, water and fertility conservation, increase in crop production, ease in cultivation, better light distribution and wind movement in the plot as the major advantages of contour cultivation (Table 6.8). Difficult to cover the polythene, earthing-up and crop management, more labour requirement, more weed problems and problem of water stagnation in the crop land were the major disadvantages perceived by farmers.

Advantages and disadvantages of the Project technologies were discussed with farmers to study the farmers' perception of the technology. They were also considered as proxy-indicators for likely future adoption. The issue was discussed again in 2003 (data not shown) in order to study if there was any change in the farmers' perceptions and decisions in 2003 compared with 2002. There were no changes, suggesting that these strengths and weaknesses of contour cultivation were firm convictions held by the farmers.

The majority of farmers from the medium wealth category and all of the rich and mixed categories perceived that downslope cultivation was less labour demanding, time consuming, difficult and expensive to apply, but the production was lower than with contour cultivation (Table 6.9). However, the poor wealth category farmers gave contrasting responses to most of

Table 6.8 Farmers' perceptions about the advantages and disadvantages of contour cultivation method, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Advantages/Disadvantages	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Advantages				
Conserves soil, water and soil fertility	1	1	1	2
Increased crop production	2	2	2	1
Easy to cultivate	3			
Increased sunlight for crops			3	
Good wind movement and better light availability for plants				3
Soil quality improved			4	4
Less labour required for harvesting				5
Easy to manage crop			6	
Less fertiliser required				6
Increases soil temperature				7
Less slippery (farmers can walk easily and work)				8
Disadvantages				
Difficult to cover polythene	1	1	2	1
Difficult to earth-up	1		1	3
Difficult for crop management	1			
Requires more labour		2		
More weed problems				2
Water stagnation in crop land	4			

Table 6.9 Farmers' comparison of different cultivation methods using different agronomic and economic criteria, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Issues	**Response**	**Number of respondents**			
		Poor	**Medium**	**Rich**	**Mixed**
Which cultivation method requires less labour and is less time consuming?	Downslope	1 (7%)	13 (93%)	12 (100%)	22 (100%)
	Contour	6 (43%)	1 (7%)	-	-
	Same	7 (50%)	-	-	-
Which cultivation method is less difficult?	Downslope	-	11 (79%)	12 (100%)	22 (100%)
	Contour	-	3 (21%)	-	-
	Same	14 (100%)	-	-	-
Which cultivation method is less expensive to apply?	Downslope	-	14 (100%)	12 (100%)	22 (100%)
	Contour	9 (64%)	-	-	-
	Same	5 (36%)	-	-	-
Which cultivation method produces more than the other?	Downslope	-	-	-	-
	Contour	14 (100%)	14 (100%)	12 (100%)	22 (100%)
	Same	-	-	-	-

these issues. 50% of the poor category perceived no difference between the two cultivation practices for labour and time requirements, 100% perceived both as equally difficult and 36% perceived both as equally expensive to apply. In addition, 43% of the poor category farmers perceived contour cultivation to be less labour and time demanding and 64% perceived it as less expensive to apply. However, there was no discrepancy in the farmers' perceptions related to production potential. This could be the reason that 100% of the farmers of all wealth categories, who participated in the group discussion, preferred contour cultivation methods.

6.3.2.2. Mulching

Existing use of straw and polythene mulch was considered. There was great variation in the use of these mulching methods. Most farmers only used polythene mulch (Tables 6.10 and 6.11).

Table 6.10 Number of respondents using straw and polythene mulch during 1999-2002 in Wang Jia catchment, PRA Survey, Kelang Village, Yunnan, China, Summer 2002.

Response	**Number of respondents**			
	Poor	**Medium**	**Rich**	**Mixed**
Straw only	0 (0%)	0 (0%)	0 (0%)	1 (5%)
Polythene only	13 (93%)	10 (71%)	12 (100%)	20 (90%)
Both	1 (7%)	4 (29%)	0 (0%)	1 (5%)

Mulching was used primarily for the maize crop in the catchment and for tobacco outside the catchment (Table 6.11). The SHASEA Project and the local market were the most important sources for mulching materials, mainly polythene.

Table 6.11 Use of different mulching methods in Kelang Village, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Location/ Wealth class	**Crops**	**Mulch materials**	**Source of mulch material**	**% Area mulched**
Poor	Maize	Polythene	Project and market	90%
Medium	Maize	Straw or polythene	Crop land, Project and market	• Polythene mulch: 90% • Straw mulch: 6%
Rich	Maize	Polythene	Project and market	95%
Mixed	Maize	Straw or polythene	Crop land, forest, market, agro-industry, and Project	• Straw: 0.2% • Polythene: 98% • Straw + polythene: 1%

Insufficient availability appeared to be one of the main reasons for low use of straw mulch (Table 6.12), as all the farmers from across the wealth categories, except the rich category, responded that the straw was not available. The rich group could acquire straw from other sources, if necessary, and therefore for them availability may not have been a problem. Similarly, all farmers responded that there was no problem in the availability of polythene mulch.

Irrespective of wealth categories, all farmers were willing to increase the use of mulch if mulching material was available. It is interesting to note that, if available, farmers were prepared to use polythene mulch on >75% of their cultivable land, but they were only willing to use straw for mulching on ≤25% of land, even if made available (Table 6.13). In fact, polythene mulch is already available in abundance in the local market, so farmers are likely to increase the area under polythene mulch provided it is available free of charge (or at low cost).

Table 6.12 Availability of different mulching materials for farmers in Wang Jia catchment, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Type of mulch	**Responses**	**Number of respondents**			
		Poor	**Medium**	**Rich**	**Mixed**
Straw	Yes	0 (0%)	0 (0%)	12 (100%)	0 (0%)
	No	14 (100%)	14 (100%)	0 (0%)	22 (100%)
Polythene	Yes	14 (100%)	14 (100%)	12 (100%)	22 (100%)
	No	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Table 6.13 Farmers' willingness to increase the area under mulching if mulching material is available, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

% area of the total land	**Number respondents**			
	Poor	**Medium**	**Rich**	**Mixed**
0-25	0	0		22 (100%): Straw
26-50	0	0		
51-75	0	0		
>75	14 (100%)	14 (100%)		22 (100%): Polythene

Temporal change in areas under different mulching systems in Wang Jia was discussed. Farmers used only polythene mulch technology in the past, which covered about <10% of the cultivable area of the catchment (Table 6.14).

Use of straw and straw + polythene mulch technology was virtually non-existent in the past. The area under polythene mulch increased to ~86% (80-90%) by the end of the Project. There was an increase in the area under straw and straw + polythene mulch, but only marginally. Farmers' expectations about the area under different mulching methods accorded with the current trend. They estimated ~87% (75-94%) of the area would be under polythene mulch in future, but only ~2% (0-6%) for straw and ≤20% for straw + polythene mulch.

Farmers' perceptions of the advantages and disadvantages of the straw and polythene mulch technology were studied. Conservation of soil, water and soil fertility; increased soil organic matter, conservation of soil moisture and decreased soil compaction (soil becomes loose) were the major advantages of straw mulch perceived by the farmers (Table 6.15).

Table 6.14 Change in the area under different mulching methods in Wang Jia catchment over 3 years (compared to 1998 or before), PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Mulching Methods	Wealth category	% Area under different mulching system		
		4 yrs ago (1998)	Now (2002)	After 3 yrs (2005)[#]
Straw Mulch	Poor	NR	2%	2%
	Medium	NR	0%	0%
	Rich	0%	5%	6%
	Mixed	NR	0.2%	0.2%
Polythene Mulch	Poor	5%	80%	90%
	Medium	5%	84%	75%
	Rich	5%	90%	94%
	Mixed	10%	90%	90%
Straw + Polythene	Poor	NR	NR	NR
	Medium	NR	6%	20%
	Rich	0%	5%	NR
	Mixed	NR	0.2%	NR

[#] = Farmers' expectation based on present trends.
NR = No response.

Table 6.15 Farmers' perceptions about the advantages and disadvantages of applying straw mulching technology, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Advantages/Disadvantages	Rank			
	Poor	Medium	Rich	Mixed
Advantages				
Conserves soil, water and soil fertility	2	1	2	1
Increases soil organic matter	1	3	1	2
Conserves soil moisture		2		
Soil becomes loose (soil compaction decreases)			3	3
Disadvantages				
Disease and insect /pest spread from mulched straw		1	1	3
Difficult for weed control		2	4	1
Straw not available (sufficient) for mulching	1	4		
Difficult to earth-up			3	2
Emergence of seed present in the straw and acts as weed		3	2	6
Difficult for inter-cropping				4
More weed problems				5

Similarly, disease and insect/pest spread from the straw used in mulching, difficult-to-control-weeds, difficulty in earthing up and more weed problems due to emergence of seed present in the straw, were the major farmer-perceived disadvantages of straw mulch technology. Farmers also mentioned unavailability of straw as a disadvantage. Farmers probably tried to indicate the reason for low use of the straw mulch technology as in fact this is not a disadvantage of the technology, but is a limitation to its application. Most of the strengths and weaknesses of straw mulch technology identified by farmers during 2003 survey (data not shown) were similar to that of the 2002 survey; however, increase in crop productivity was only mentioned during the 2003 survey.

Good seed emergence, increase in crop production, soil and water conservation, soil moisture conservation and reduction in fertiliser requirements were the major farmer-perceived advantages of polythene mulch technology (Table 6.16). Lack of money to purchase the material, adverse effect on the succeeding crop (if not disposed of properly after use), increased environmental pollution and difficulty in removing the polythene after use were the major disadvantages of the technology. Farmers' responses about the strengths and weaknesses of the polythene mulch technology during 2003 were similar to that of the 2002 survey.

Table 6.16 Farmers' perceptions about the advantages and disadvantages of polythene mulching technology, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Advantages/Disadvantages	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Advantages				
Good seed emergence	1	1	1	4
Increases crop production	2	2	2	1
Conserves soil and water		5		2
Conserves soil moisture	3	4	3	
Requires less fertilisers		3	4	5
Increases soil temperature	4	6		3
Easy to control weeds			5	
Crop matures earlier	5	7	7	6
Less labour required for inter-culture operation	6			
Reduction in crop lodging problems			6	
Crop grows fast			7	
Less labour required compared to straw + polythene mulch				7
Disadvantages				
Lack of money to buy polythene	1	2		
Adverse effect on succeeding crop growth, if the polythene is not removed			1	
Increased environmental pollution		1	3	2
Difficult to take out the polythene after the crop harvest	2		4	1
Polythene mulch is not good for crops having short plant height because of the increased temperature at ground level			2	
More labour required (labour intensive)		3	5	

6.3.2.3 Intercropping

Between 32-71% of the participants of the group discussion practised intercropping (Table 6.17). Farmers' estimates of the percentage of land area under intercropping systems were generally about 10%, except in the case of the response from the medium wealth category, which was 50%.

Table 6.17 Number of households practising intercropping in Wang Jia catchment, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

	Poor	**Medium**	**Rich**	**Mixed**
Number of respondents practising intercropping	10 (71%)	8 (57%)	8 (67%)	7 (32%)
% area in the catchment under intercropping systems	5	50	8	10

Farmers' responses about temporal changes in the area under intercropping also revealed a perception of decreasing area under intercropping (Table 6.18). Intercropping used to be practised in ~60% (50-80%) of the catchment area in the past (1998), which reduced to ~18% (8-45%) during 2002, and farmers did not anticipate significant changes in the future, except for the rich group.

Table 6.18 Percentage land area under intercropping system in and around Wang Jia catchment, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Wealth Category	**% Area under intercropping system**		
	4 yrs ago (1998)	**Now (2002)**	**After 3 yrs (2005)[#]**
Poor	Do not know (but more than in 2002)	8 (area has decreased than 1998)	8
Medium	50	45	45
Rich	50	8	20
Mixed	80	10	10

[#] = Farmers' expectation based on the present trend.

Adverse effects on both main and companion crops due to competition and difficulty in controlling weeds were the major reasons for not practising intercropping (Table 6.19).

Advantages and disadvantages of intercropping systems were discussed with the farmers in order to study their perceptions of the effects of the technology on the environment. Increases in production and income, possibility to grow more than one crop, conservation of water and improvement in soil fertility due to the inclusion of leguminous crops were the major advantages of the intercropping system perceived by the farmers (Table 6.20). Competition between main and companion crops, low total income, requirement of more fertilisers, difficulty in controlling weeds and earthing up were the major disadvantages. Farmers' responses about the strengths and weaknesses of intercropping technology during the 2003 survey (data not shown) were similar to the 2002 survey.

Table 6.19 Farmers' perceptions about the reasons for not practising intercropping/ mixed-cropping (the problems associated with the adoption of intercropping/ mixed-cropping technology), PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Reasons	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Adverse effect on maize (main crop)	1	1	1	1
Maize crops adversely affect the legume yield	2			
The land is good, so not necessary to use intercropping		2		
Not enough sunlight for crops (competition effect)			2	3
Difficult to control weeds			3	2
Air movement in the crop land is not good under intercropping conditions		3		

Table 6.20 Farmers' perception about the advantages and disadvantages of intercropping system, PRA Survey, Kelang village, Yunnan, China Summer 2002.

Advantages/Disadvantages	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Advantages				
Increases production and total income	1	1		2
Possible to grow more crops on the same land			1	1
Conserves water		2		
Improves soil fertility, due to inclusion of leguminous crops		3		3
Good utilisation of available crop land		4		
Disadvantages				
Competition between main and companion crops	1			
Total production is low			1	
Adverse effect on main crop by companion crop		2		1
Wind movement is not good and competition for light		1	4	4
Requires more fertilisers			2	
Difficult to control weeds		3		2
Difficult to earth-up				3
Decreases soil temperature			3	
We do not want to grow low productive crops			5	
More disease and pest problems			6	
Adverse effect on high yielding crops			7	

6.3.2.4 Tree planting

Various issues about the tree planting scheme were discussed with the farmers. Irrespective of wealth categories, all farmers liked the idea of planting trees on crop land (agro-forestry) and also the tree species selected for planting on their land. In addition, all farmers responded that they would choose the same species if they had to plant trees on similar land.

As the household survey revealed that >50% of farmers had not planted trees (Table 5.19), the reasons for not planting trees were discussed. Farmers identified small land holdings, pre-existing trees in the land, tree-crop competition, low economic return from trees and reduction in area for field crop production as important constraints for the adoption of trees (Table 6.21).

Table 6.21 Reasons for not planting trees (problems associated with the adoption of agro-forestry (tree planting) technology), PRA Survey, Kelang village, Yunnan, China Summer 2002.

Reasons	**Rank**			
	Poor*	**Medium**	**Rich**	**Mixed**
Small land holding (arable land)		1		
Farmers have already planted trees in their land, so they do not want to plant more trees			1	
Economically unprofitable		3		1
Adverse effect (shading effect) on field crops			2	
Reduction in area for field crop production			3	2
Not easy for management of the crop under agro-forestry conditions		2		4
Farmers decide to plant types of crops /trees based on their land type and quality. If land suitable for trees is unavailable, they do not plant trees				3
Disease and insect/pest problem from trees to crops			4	

Note: * = Not asked of poor group.

The extent of visits to the catchment plantation area by farmers participating in the discussion was discussed. The number of visits to the plantation area was a proxy-indicator for farmers' interest in tree planting. Farmers had considerable interest in the technology, as between 43 and 100% of respondents had visited a tree plantation area at least once (Table 6.22). The rich category was more interested in tree planting activity than the poor and medium categories.

Table 6.22 Number of farmers visiting the plantation area within the last year, PRA Survey, Kelang village, Yunnan, China Summer 2002.

Number of visits	**Number of respondents**			
	Poor	**Medium**	**Rich**	**Mixed**
None	4 (27%)	8 (57%)		1 (5%)
One		1 (7%)		
Two		1 (7%)		
Three		1 (7%)		
More than 3	11 (73%)	3 (22%)	12 (100%)	21 (95%)

All farmers across the wealth categories liked the idea of tree planting. Increases in household income, soil and water conservation, environmental improvement and financial security for the future were the major reasons for this preference (Table 6.23).

Table 6.23 Reasons for liking the idea of tree planting, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Reasons	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Increased income	1	2	2	1
Conserves soil and water	2	1	1	2
Good for future			4	3
Improves the view of the environment (aesthetic value)	4	3		
Improves environment		4	3	4
Increases greenery	3			
Provides shade area for resting during hot days		5		

The strengths and weaknesses of sweet chestnut and prickly ash planting identified by farmers during the 2003 survey were similar to the reasons for not planting trees (Table 6.21) and reasons for liking the tree planting technology (Table 6.23) mentioned by farmers during 2002 survey.

6.3.2.5 Irrigation system

Low use of the irrigation facility by farmers was revealed from the household survey (Tables 5.24 and 5.26). So access to, and actual use of, the irrigation facility was discussed with farmers. Farmers reported that ~60% of farming households in Wang Jia catchment had access to the irrigation facility, of which ~10% were using it. Similarly ~40% of land in the catchment could be irrigated by the system, however, only ~10% of the area was being irrigated.

Maintenance requirements of the irrigation system

Farmers' views about the maintenance requirements of the irrigation system were considered as a proxy-indicator for their perceptions of future use of the system. The irrigation system was a recently built structure, so it was working properly without requiring major maintenance and repair. Moreover, the Project was doing all the maintenance and repair work and farmers had little information about the amount and cost of maintenance, so farmers said what they could do to run and use the system rather than what they think will be required. It was understood from the way farmers interacted in the discussion that their response was based on guesswork, rather than their experience.

The rationale behind the discussion was that farmers would manage and use the system if they thought that the system would not require much maintenance and would not be difficult for them. Farmers' speculation of more and difficult maintenance requirements would indicate that they had decided it was a difficult job and were not interested in managing and using the system. However, farmers responded to this question in a different way than expected. They outlined what they could afford to do, rather than what they thought would be necessary.

Poor category farmers were ready to repair and maintain the system up to 10 times per year. However, rich and mixed groups were prepared to do it only two or three times per year, respectively. A different response came from the medium group, who were prepared to carry out whatever requirement would be needed to run the system.

The farmers considered that the irrigation system was new, so the maintenance frequency was not high at present, but when the irrigation system became old, it might require major maintenance. Farmers felt they could afford the maintenance now, but if major maintenance was required in the future then it would be difficult for them to afford the cost. In addition, if the system required experts to repair it then it would be difficult for them. In this situation, Project or Government assistance would be required.

Changes in the cropping system due to the irrigation system

Farmers' perceptions about major changes in the cropping systems in the catchment due to the irrigation system were discussed (Table 6.24). Farmers from across the wealth categories shared the same view that there was no change in the cropping system due to the irrigation system, but they were anticipating changes in future. It would become possible to replace maize with income-generating options like tobacco, vegetables, flowers and fruit trees after the project period. So the area under tobacco, vegetables, flowers and fruit (peach, sweet chestnut, plum) trees was likely to increase after project completion.

Good seedling emergence, increased capacity to combat drought, increased crop production and thereby increased household incomes were the major advantages of the irrigation system perceived by farmers (Table 6.25). Although farmers articulated well the advantages of the irrigation system, only a few farmers used it. The use of irrigation during the winter (drought season in Yunnan) was even lower, which could be due to the farmers' perception of the high labour costs associated with the use of irrigation compared to the increase in income by its use. Farmers were willing to use irrigation for high value crops, where they considered it an advantage.

Table 6.24 Farmers' perceptions about the changes in the cropping system of Wang Jia catchment due to the irrigation system, PRA Survey, Kelang Village, Yunnan, China, Summer 2002.

Wealth category	**Now (Summer 2003)**	**After the Project**
Poor	No change	Area under tobacco is likely to increase
Medium	No change	Area under tobacco and during the summer, wheat/ pea with rape seed/mustard or grasses will increase. The cropping pattern will change to • Maize - tobacco or fruit tree • Wheat/pea - rape seed/mustard or grasses
Rich	No change	Area under tobacco and vegetable will increase
Mixed	No change	The area under tobacco, vegetables, flower, and fruit (peach, sweet chestnut, plum) trees is likely to increase. The cropping pattern will change to • Maize to tobacco • Maize to vegetable • Maize to flower, fruit (peach, sweet chestnut, plum) trees

Similarly, insufficient irrigation ponds, danger to children and livestock posed by unsecured access to ponds, damage to pipes due to shallow burying and too much water in the plots around the pond due to over-flowing were the major limitations of the irrigation system. Farmers' responses about the strength and weaknesses of the irrigation technology during the 2003 survey (data not shown) were similar to the 2002 survey.

6.3.2.6 Dissemination and initial adoption/adaptation of Project technologies

Dissemination activities conducted by the Project and initial adoption/adaptation of the Project technologies by the farmers were discussed during summer 2003. Issues related to degree of farmers' awareness, training activities, access and sources of information, extent of initial adoption/adaptation and strength/weakness of the Project technologies were discussed.

The level of farmers' awareness about the current status of the Project was studied, with the assumption that those farmers who had been following the progress of Project activities would be aware of the current status. All of the respondents had at least a reasonable level of awareness about the Project (Table 6.26). About 50% of the medium and rich category participants had a good knowledge about the current status of the Project, but none of the poor category was well aware.

Table 6.25 Farmers' perceptions about the advantages and disadvantages of irrigation facility, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Advantages/Disadvantages	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Advantages				
Good seedling emergence	1		3	1
No problem of drought stress/ possible to save the crop from drought		1	1	3
Increase in crop production/income	3	2	2	2
Reduction in the labour requirement because the irrigation system is in the vicinity	2			
Possible to plant high value crops		3		
There is no irrigation system on neighbouring sloping uplands. So, having irrigation system in such sloping upland is a matter of pride	4			
Fast crop growth			4	
Possible to plant the crop early				4
Availability of water to use the pesticide in the vicinity of crop land, which saved labour		4		5
Good crop vigour			5	
Disadvantages				
The irrigation ponds are not sufficient	1	1	1	1
The ponds are dangerous to cattle and children	2	2	2	2
The pipes have not been buried deep, due to which damage can occur during tillage /cultivation		3		
When the pond is full, the water spills on to the crop land. There is no drainage channel			3	
The crop land around the pond is adversely affected by trampling people		4	4	3
Insufficient water from source			5	
Crop land is occupied by the irrigation ponds			6	

Table 6.26 Farmers' awareness about the Project in Wang Jia catchment, Yunnan, China, PRA Survey, Summer 2003.

Level of awareness	**Number of responses**			
	Poor	**Medium**	**Rich**	**Mixed**
Well aware	0	6	3	1
Some awareness	16	12	7	15
No awareness	0	0	0	0

Details of training (e.g. frequency, type, wealth category and gender differentiation) were discussed to study the factors affecting farmers' awareness and adoption. Most surveyed farmers had received at least one training opportunity on Project technologies (Table 6.27). Farmers identified only three areas of training they had received from the Project. However, further discussion with farmers revealed that information about new Project technologies was embedded in the broad subject. Many short training sessions for different technologies would have been organised coinciding with the right time of use of technology in the field. This would provide opportunities to demonstrate the technologies in real life situations.

Table 6.27 Number of farming households participating in different training activities provided by the Project in Kelang Village, Yunnan, China, PRA Survey, Summer 2003.

Area of training	**Number of farmers**			
	Poor (N=16)	**Medium (N=18)**	**Rich (N=10)**	**Mixed (N=16)**
a. Improved maize cultivation practices	15	18	8	16
b. Improved wheat cultivation practices	0	6	7	3
c. Planting techniques of sweet chestnut, prickly ash and pine trees	0	0	2	4
Total number of farmers participating in any of the training activities	15	18	8	16

The Project did not operate gender- or wealth-differentiated training programmes. A large proportion of households sent female participants to the training programme (Table 6.28), and participation was normally either only male or female.

Table 6.28 Number of farming households who participated in different training activities provided by the Project in Kelang Village, Yunnan, China, PRA Survey, Summer 2003.

Participants	**Number of farmers**			
	Poor	**Medium**	**Rich**	**Mixed**
Male only	9	9	3	11
Female only	6	6	3	2
Both	0	3	2	3
Valid N	15	18	8	16

Access to information plays a key role in the adoption of changing technology. So the issue was covered in group discussions. Chinese farmers have access to a number of sources of information on agricultural technology. There was no obvious change in access to information between the pre- and post-Project periods (Table 6.29).

There were obvious changes in the source of information for the farmers between the pre- and post-Project periods. The SHASEA Project appeared to be one of the most important information providers during the Project period (Table 6.30). However, it was perceived that the

SHASEA Project team worked with local Government officials for implementation of Project activities and subsequent dissemination of outcomes in the catchment.

Table 6.29 Access to agricultural technology-related information for farming households in Kelang Village, Yunnan, China, PRA Survey, Summer 2003.

Received information about agricultural technology	**Number of responses who received information**			
	Poor	**Medium**	**Rich**	**Mixed**
Before the Project period (before 1998)	16	18	7	9
During the Project period (after 1998)	16	18	9	16
Total N	16	18	10	16

Table 6.30 Sources of agricultural technology-related information in Kelang Village, Yunnan, China, PRA Survey, Summer 2003.

Sources of information	**Number of responses**			
	Poor	**Medium**	**Rich**	**Mixed**
Before the Project period				
Government agencies	16	17	7	9
Project	-	-	-	-
Agricultural magazines	1	3	0	0
Radio/TV	0	13	5	5
Neighbours	7	11	1	8
Relatives	5	7	0	3
Others (specify)	11	0	0	0
Valid N	*16*	*18*	*7*	*9*
During the Project period				
Government agencies	0	10	0	16
Project	16	18	9	16
Agricultural magazines	1	1	0	0
Radio/TV	2	12	0	2
Neighbours	2	7	0	0
Relatives	1	1	0	0
Others (specify)	2	0	0	0
Valid N	*16*	*18*	*9*	*16*

The dependence on neighbours and relatives for information about improved agricultural technologies was more important in the poorer section of society. Poor and medium categories mentioned neighbours and relatives as sources of information, which was cited much less by the rich category. The poor category even mentioned farmers from other villages as a source of information. In addition, the medium and poor categories received information from more sources than the rich. It indicates that medium and poor categories were more proactive in searching the information than the rich category. This could be because medium and poor category farmers were more dependent on farm income for their livelihood than the rich category, who earned much of their income from off-farm activities.

Adoption of Project technology in Wang Jia catchment was discussed with the farmers' groups. Farmers' estimates about the extent of adoption were studied. Farmers perceived and estimated high adoption of polythene mulch, contour cultivation, sweet chestnut and intercropping technologies at both household and catchment level (Table 6.31), of which polythene mulch and contour cultivation technologies were adopted by almost all farming households. Out of 27 hectares of total cultivable land in the catchment, farmers estimated ~17 hectares (63%) were covered by both contour cultivation and polythene mulch. Despite the large number of households using irrigation (80) and intercropping (50), the land area under these technologies was low (5.33 ha and 3.33 ha, respectively). Similarly, farmers' perceptions about the adoption of straw mulch technology were low both at household and catchment level. This information closely matched the information collected from the household survey, except for irrigation technology.

Table 6.31 Farmers' response about the level of adoption of Project technology by farming households in Wang Jia catchment, Yunnan, China, PRA Survey, Summer 2003.

Technology	**Number of farmers adopting the technology**			
	Poor* (N=16)	**Medium*** (N=18)	**Rich*** (N=10)	**Mixed****
Contour cultivation technology	16	18	10	145
Straw mulch technology	6	3	3	10
Polythene mulch technology	16	18	9	120
Intercropping technology	4	7	3	50
Sweet chestnut plantation	9	7	6	50
Prickly ash plantation	0	2	3	10
Irrigation scheme	1	9	7	80
Total	-	-	-	145

Notes:
* - The figures represent the number of respondents in the PRA exercise adopting the technology.
** - The figures represent the catchment total, i.e., total number of households in the catchment adopting the technology.

6.3.2.7 Environmental impact of Project activities

Existing practices of controlling soil and water losses from their crop land and vicinity were discussed with farmers in order to compare their practices with improved practices. All groups reported that planting, protecting and conserving the vegetation were their major approaches to reducing soil and water losses (Table 6.32). In addition, reducing the slope angle of the crop land by converting the sloping land into terraces and reducing the speed of the downflow of water by using contour cultivation were the other important practices adopted by farmers to reduce soil and water losses. Farmers' practices in this regard were similar to the researchers' recommendations.

Table 6.32 Farmers' practices of controlling or reducing runoff, sediment loss and soil erosion, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Farmers' practice	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Plant trees		1	1	1
Protect forest in the catchment, plant trees in the gullies	1			
Plant grass		2		
Convert sloping land into terraces			2	
Use contour cultivation	2	3	3	2
Use of furrows (small channels) to guide the excess water to a gully				3
Use of local resources (wood, grass, mud and sand) to control run off and erosion	3		4	4
Convert crop land into forestland		4		
Polythene mulch		5		
Straw mulch		6		
Prohibition to deforestation and cultivation of forestland		7		

Any discrepancies between farmers' practices and Government and Project researchers' recommendations were further studied by discussion of farmers' perceptions about the differences in the farmers' and Project's approach. During the discussion, all wealth categories reported that the farmer practice of controlling runoff and soil loss was similar to the Project's approach. In addition, the mixed group explained the issue in a more meaningful way. They perceived that most of the farmers' practices were similar to the Project's approaches, but some, particularly the use of scientific and large-scale activities (viz. construction of check dam, use of information from gauge station and weather station) were different to the farmers' practices for controlling soil erosion. Farmers used locally-available material (e.g. wood, sand and stone) to control runoff and soil loss. Their scale of operation was small; for example, shallow furrows to drain the water from relatively small areas, compared to the deep and large-sized drainage canal constructed within the Project to drain the excess water from fairly large areas of the catchment.

The extent of adoption of Project technologies by farmers for controlling runoff and soil loss was discussed. Very high adoption of Project technologies was found, as all farmers from all wealth categories used the Project technologies for controlling runoff and soil loss during 2002 (Table 6.33).

Table 6.33 Number of respondents who adopted the Project's approach for controlling runoff, sediment loss and erosion, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Response	**Number of respondents**			
	Poor	**Medium**	**Rich**	**Mixed**
Implementers	15 (100%)	14 (100%)	12 (100%)	22 (100%)
Non-implementers				

Reasons for the adoption were discussed in order to study the farmers' understanding of the Project's technologies. Conservation of soil, water and soil fertility, decrease in landslide frequency, increases in crop production and making the environment greener and beautiful were the major farmer-perceived reasons for the adoption of Project technologies (Table 6.34).

Table 6.34 Reasons for adoption of Project approach for controlling runoff, sediment loss and erosion, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Farmers' practice	**Rank**			
	Poor	**Medium**	**Rich**	**Mixed**
Soil water and soil fertility conservation. Decreased frequency of landslides	1	1	1	2
Increased crop production	3	3		1
Farmers believe in science	2			
To make environment greener		2		
To make the environment beautiful (to improve the environment)			2	
To conserve soil fertility (more vegetative cover)			3	
More area available for tree plantation and crop cultivation due to decreased landslides				3
Good method	4			
Good for future		4		

Changes in the natural resources of Wang Jia catchment due to Project activities were discussed with farmers' groups. Farmers perceived that Project activities had positive effects on natural resources, as forest resources were estimated to have increased by ~38% (20-60%), water resources increased by ~51% (40-65%) and soil fertility increased by ~41% (20-60%), while soil and water losses decreased by ~66% (50-90%) (Table 6.35). The percentage figures were farmers' estimates, which were quantified based on their perceptions. The farmers' rating of the changes in natural resources due to Project activities was generally high. The rating of poor and medium wealth categories was particularly high compared to rich and mixed categories.

The reasons for changes in the natural resources were discussed with farmers during the 2003 survey. Farmers were very good at articulating the reasons for the changes, in particular:

plantation of trees and protection of forest areas (control grazing, deforestation and encroachment of forest area), and soil and water conservation (use of contour cultivation, increased use of manure, and construction of check dam, Table 6.36).

Table 6.35 Farmers perceptions about the effect of Project activities on the natural resources of Wang Jia catchment, Yunnan, China, PRA Survey, Summer 2003.

Natural resources	**Effect (Increased/ Decreased)**			
	Poor	**Medium**	**Rich**	**Mixed**
Forest resources	I: by 60%	I: by 50%	I: by 20%	I: by 20%
Water resources	I: by 40%	I: by 65%	I: by 50%	I: by 50%
Soil fertility	I: by 50%	I: by 60%	I: by 35%	I: by 20%
Soil and water loses	D: by 90%	D: by 75%	D: by 50%	D: by 50%

(Note: I = Increased, D = Decreased)

Similar issues were discussed during the 2002 survey, but in a broader context. The effect of Project activities on natural resources of the catchment was discussed without going further into different aspects of natural resources. Farmers perceived the decrease in the frequency of landslides, floods and runoff /discharge from the gully and improvement in land quality of the catchment to be due to Project activities (Table 6.37). Moreover, the catchment looked greener due to increased vegetation cover because of the increased number of trees and grasses. Despite the difference in the depth of discussion, these views were clearly similar during 2002 and 2003.

6.3.2.8 Farmers' additional comments

At the end of the PRA exercise, farmers were asked for any additional comments and suggestions about the Project. They were encouraged to point out weaknesses of the Project in order to make future activities more helpful for farmers. However, no critical comments were forthcoming, but further appreciative points were made (Table 6.38).

One farmer representing the rich group wrote an appreciative note: "*The Project has been implemented in Kelang village in order to develop sustainable agricultural technologies, and increase farmers' income. This is a good example of sustainable agricultural development. Thank you for your help*".

Table 6.36 Farmers' perceptions about the factors responsible for the change in the natural resources of Wang Jia catchment, Yunnan, China, PRA Survey, Summer 2003.

Natural resources	**Wealth category**			
	Poor	**Medium**	**Rich**	**Mixed**
Increase in forest resources				
Trees and grasses planted	*	*	*	*
Soil and water conserved	*	*	*	
Animal grazing controlled	*			*
Environment conserved	*			
Better management of the catchment		*		
Deforestation controlled			*	
Check dam constructed				*
No forest encroachment				*
Provision of forest guard/watchman				*
Increase in water resources				
Trees and grasses increased	*	*	*	*
Contour cultivation technology used		*		*
Soil and water conserved	*		*	
Check dam reduced soil losses			*	*
Flooding decreased	*			
Irrigation system constructed		*		
Better protection of forest			*	
Forest encroachment controlled			*	
Polythene mulch technology used				*
Increase in soil fertility				
Soil and water conservation activities conducted	*	*	*	*
Tree leaves and grass become manure	*	*		*
Straw mulch technology used	*	*		*
Trees planted		*	*	
Contour cultivation technology used		*		*
Polythene mulch technology used		*		*
Access road made it easy to transport and use more FYM in the catchment		*		
Scientific methods of crop production used			*	
Decrease in soil erosion, soil loss, sediment loss				
Check dam constructed	*	*	*	*
Contour cultivation technology used	*	*		*
Forest area increased	*	*	*	
Animal grazing controlled		*	*	
Trees and grass have grown well			*	*
Planting grasses reduced soil & water losses		*		
Training in tree planting technology		*		
No forest encroachment			*	

Table 6.37 Farmers' perceptions about the effect (both positive and negative) of Project activities on natural resource within the catchment, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Effects	**Wealth category**			
	Poor	**Medium**	**Rich**	**Mixed**
Positive effects				
The frequency of landslides decreased	*		*	*
Flood frequency decreased		*	*	*
Land quality improved	*			*
Decreased runoff/discharge from the gully is also reduced	*		*	
More trees and more grasses –the environment becomes greener		*		*
The grass is growing in the gully. Rehabilitation (stabilisation) of the gully is taking place	*			
The upper part of the catchment appears greener due to tree planting	*			
More dams more soil in upper part of the gully		*		
Gullies become narrower		*		
Easy access to water (irrigation) sources			*	
Increased availability of forage (grasses/weeds) and there are more trees due to which the environment appears greener			*	
Availability of irrigation sources				*
The gullies become shallow (before they were deep)				*
Less sand and stone in the gully (means more soil – sign of rehabilitation).				*
Negative effects				
Cultivation of the crop is more difficult due to presence of trees in the crop land	*			
None		*	*	*

6.3.3 Farmers' workshop for participatory catchment evaluation

The objective of this workshop was to study farmers' perceptions and evaluation by direct observation of the Project efforts to rehabilitate environmental conditions within the catchment. This was achieved by observing, examining and comparing the environmental situation of Wang Jia catchment and Lai Zi catchment (an adjoining catchment) by participating farmers.

6.3.3.1 Development of criteria (indicators)

Farmers developed their own criteria for the evaluation and comparison of the catchments. Prior to this, the following broad criteria were identified with a view to check whether farmers considered these broad issues:

- Erosion scars (number and size of the erosion scars).

- Vegetation cover (forest area, grass cover area and crop area).
- Eroded area.
- Presence of gullies (number of gullies).
- Size and depth of gullies.
- General crop vigour (soil fertility status).

Table 6.38 Food for the road – farmers comments at the end of group discussion, PRA Survey, Kelang village, Yunnan, China, Summer 2002.

Wealth category	**Comments**
Poor	Not discussed.
Medium	• *The Project introduced improved technologies and increased the crop productivity.* • *The irrigation system is good, because of which quality of crops is improved.* • *We want better technologies and the best scientists who show us how to use the technologies.* • *We want special person to manage the catchment, such as the irrigation ponds and trees.* • *The farmers hope the government help and care for them as much as the foreigners.*
Rich	• *We want more scientific knowledge and technologies from the Project in order to make agriculture more sustainable and improve farming systems.* • *We want technologies about the medicinal plants, ornamental (flower) plants, and other new crops. We also want the Project to make available new improved breeds of livestock.* • *And other scientific agricultural technologies.*
Mixed	• *Help us to manage the catchment.* • *Bring new technologies for us - guide us always.* • *Bring new types of seed and animal breeds.* • *Do not forget us - we will not forget you.* • *Always welcome the foreigners.*

The indicator development exercise was conducted with the expectation that it would provide a basis for the comparison of researchers' and farmers' criteria. It would provide information on whether any parameter important for researchers was also important for the farmers. It was also planned that if farmers did not mention any of the criteria identified by researchers, then the importance (or otherwise) of researchers' criteria should be discussed. The ultimate aim was to check the parity between researchers' work and farmers' understanding and perception. However, all the broad criteria identified by researchers were mentioned by the farmers, which suggests that farmers' understanding accorded with scientific understanding.

Participating farmers developed the following criteria (indicators) for the observation, examination and evaluation of the catchments:

1. Conditions of check dams and gullies.
2. Soil and water conservation.
3. Extent of landslides and soil loss.
4. Vegetative cover (number of trees, extent of vegetation cover).
5. Vegetation cover and vigour.
6. Management of the catchment (control of grazing, trees and vegetation condition).
7. Cultivation and cropping practices.
8. Crop performance and crop diversity.
9. Crop production and productivity.

The following additional criteria (indicators) were mentioned by farmers after visiting the catchments:

10. Steepness of sloping land.
11. Soil type and quality.
12. Water sources and availability.
13. Access road.
14. Use of grass strips.
15. Crop cover (area).

6.3.3.2 Observation, evaluation and comparison of catchments

Farmers observed, evaluated and compared the environmental condition of Wang Jia and Lai Zi catchments, based on their criteria (Plate 6.2). The findings of the farmers' workshop are presented below. Farmers considered 15 different indicators to compare the two catchments (Table 6.39). Their responses focussed on five main aspects, as follows:

a. Current situation of soil and water losses

Farmers considered the condition of gullies and check dams, and the extent of landslides to compare soil and water losses from these catchments. Farmers concluded the condition of gullies to be better in Wang Jia because of the presence of sidewalls in the gullies, less deep gullies and the presence of grasses and bushes in gullies. Check dams were constructed only in Wang Jia, which rehabilitated the gully and reduced soil water losses. Similarly, the number of gullies and landslides were reduced in size and number in Wang Jia.

Plate 6.2 Farmers' workshop for participatory catchment evaluation in Wang Jia catchment, 2002. (Source: Author)

b. Vegetation cover and natural resources

Issues like vegetation cover and vigour and soil quality were considered. Wang Jia was reported to have better vegetation cover and vigour, with more trees and bushes, well-grown tall trees and a greener appearance.

Farmers perceived that soils in Wang Jia were loose with small amounts of gravel and stones, whereas in Lai Zi catchment the soil was compacted and hard with large amounts of sand, gravel and stones. Soil depth in Lai Zi was shallow and deep tillage was not possible. Fertility status of the soil was better in Wang Jia, with improved soil moisture status.

Table 6.39 Farmers' overall evaluation and comparison of Wang Jia and Lai Zi catchments, Farmers' Workshop, 11 August 2002.

Wang Jia catchment	**Lai Zi catchment**
Conditions of gullies and check dams	
• Lack of natural sources of water (the available water was brought from the neighbouring (other) catchment	• Presence of two natural water sources (natural springs)
• Slope less steep than Lai Zi	• Slope was more steep than Wang Jia
• Less soil and water loss	• More soil water loss. Occurrence of landslides is more likely
• Presence of stones on the sidewall of gullies (not easily erodible)	• Many large gullies, few stones on the side of the gullies
• More grasses and bush on the gullies	• Less grass and bushes on the side of the gullies
• The gullies are less deep compared to other catchment	• The gullies are very deep
• There are several dams in the Project catchment	• No dams in the gullies
Situation of soil and water losses	
• Effective soil and water conservation ◦ Use of contour cultivation ◦ Many trees planted ◦ Grass strips used ◦ Check dams constructed ◦ Fewer gullies present ◦ Grasses and bushes in the gullies ◦ Fewer landslides	• No soil and water conservation effort ◦ Use of downslope cultivation ◦ More bare land ◦ No grass strips ◦ No check dams ◦ More gullies present ◦ Less grasses in the gullies ◦ More and larger landslides
Extent of landslides (size, number)	
• Fewer and smaller landslides	• More and larger landslides
• The gully is small	• The gully is large
• Presence of grasses (vegetation) inside and outside the gully	• Presence of few grasses in the gully
• Construction of stone wall on the side of the gully	• Presence of fewer stones and more soil on the sidewall of the gully
Situation of vegetation and greenery (number of trees, vegetation cover)	
• More trees, especially sweet chestnut	• Fewer trees compared to Project catchment (sweet chestnut)
• Number of naturally occurring trees is greater	• Less naturally occurring forest compared to Project catchment
• Planting trees is not easy because of insufficient water in vicinity, however, some farmers planted trees and some farmers not (the decision was based on personal judgements)	• Easy to plant trees, because of the availability of water
Vegetation cover and vigour	
• Good vegetation cover and vigour ◦ More trees and bushes ◦ Tall trees ◦ The catchment looks more green	• Poor vegetation cover and vigour ◦ Fewer trees ◦ Short trees ◦ The catchment looks yellow and brown due to poor vegetation cover

Wang Jia catchment	Lai Zi catchment
Management of the catchment (control of grazing and vegetation management)	
• Management of the Project catchment is easy because the whole catchment is under one village • Entry of livestock in the catchment has been prohibited, grazing stopped • Fodder/forage harvesting is controlled • Cut-down (deforestation) of trees controlled, the vegetation protected from fire • Provision of staff for the repair and management and use of the irrigation ponds	• Management of the catchment is difficult because the catchment area is under two villages • The catchment is not managed, and looked after by anybody, so people can do whatever they want to do; free grazing is practised
Cultivation and cropping practice	
• Improved agricultural technology used • Use of contour cultivation • Straw and polythene mulch used • Greater area under intercropping system	• Use of traditional farming technology • Downslope cultivation practised • No use of straw mulch and few use polythene mulch • Less use of intercropping
Crop performance	
• Use of improved varieties • Homogeneous height and thick stem of the maize crop • Managed by the Project	• No use of improved varieties • Heterogeneous plant height and thin/weak stems of maize crop • No organised management of the catchment
Crop production and productivity	
• The production of maize is expected to be high (expectation based on the crop condition) • Production of potato, soybean, French bean, sunflower and sweet chestnut is expected to be high	• The production of maize is expected to be low (the crop was heterogeneous and vigour was poor) • Low crop productivity
Steepness of sloping land	
• The steepness of the slope is less compared to the other catchment • The area of sloping land is less than the other catchment • Tractor can be used to till some of the sloping land	• The steepness of slope is more than the Project catchment • The area of sloping land is more than the Project catchment • The steepness is great, so only humans and livestock can work
Soil types and quality	
• Red soil, clay, loose soil • Soil is deep • Can be tilled deeply • Soil fertility is good • Good soil moisture • Less soil-water and soil fertility losses • Few and small stones present in the crop land	• Sandy soils, lots of stones in the crop land, hard soil, with poor quality • Less (thin) soil depth • Shallow tillage – not possible to till deep • Poor soil fertility • Poor soil moisture • Large soil-water and fertility losses • More and large-sized stones present in the crop land

Wang Jia catchment	**Lai Zi catchment**
Existence of water sources and number of irrigation ponds	
• Presence of ponds for irrigation	• The water reservoir is for drinking not for irrigation
• More irrigation ponds	• Few reservoirs
• The irrigation ponds are dangerous to children and livestock (there is no fence or cover)	• The water reservoir is not dangerous (tank)
• The water has been brought from far using pipes	• The source of water is nearer than the source of catchment water
Access road	
• Near the main road	• Far from the main road
• Access road from the catchment to the main road	• Only trekking trails present in catchment (no access to the main road)
• Grass cover on the sides of the access road	• Poor grass cover on the side of the trails
• Smooth (fewer stones) road	• More stones on the trails
• No livestock on the road.	• Livestock wondering around the trails
Use of grass strips	
• Presence of man-made grass strips, the growth and vigour of grass strips are good	• No grass strip in other catchment
Crop cover (area)	
• Most of the catchment area under maize	• Large area under tobacco and small area under maize
• More sweet chestnut trees	• Few sweet chestnut trees
• Large area under leguminous crops	• Small area under leguminous crops
• Small area under potato	• Large area under potato
• More sunflower and pumpkin	• Small area under sunflower or pumpkin
Overall comparison	
• Project is managing and improving the catchment	• No catchment management
• Provision of staff to look after the catchment	• No provision of staff
• Grazing, cutting trees, grass/weed collection is prohibited. Encroachment on forestland is controlled	• No control over harmful activities
• Access road to the main road	• No access road (just trekking trails)
• Numbers of irrigation ponds are more than in other catchment	• No pond for irrigation; only reservoir for drinking water
• More check dams. Good quality dam	• No check dam
• More trees	• Few trees
• Few landslides	• More landslides
• The number of gullies is less, less deep and less steep compared to the other catchment	• Presence of more gullies, deep gullies and steep gullies
• Less soil and water loss	• Large soil-water loss
• Soil quality is good	• Poor soil quality
• Light distribution in Project catchment is better than the other catchment, because of the less steep slope	• Poor light distribution, because of steep slopes

c. Infrastructure and catchment management

Farmers' considered provision of a 'caretaker' in the catchment, access road, check dams and irrigation system to compare the infrastructure and management efforts in the two catchments. The Project support in hiring a caretaker, who was instrumental in controlling grazing, deforestation and forest encroachment in Wang Jia catchment, was well appreciated by participating farmers. In addition, farmers presented scientific approaches of conservation and use of natural resources (fodder/forage), management and use of the irrigation system and the control of hazards such as fire as evidence of better management in Wang Jia, which was lacking in Lai Zi. An access road, check dams and irrigation systems were constructed only in Wang Jia.

d. Use of environment friendly technologies

Farmers concluded that cultivation and cropping practices in Wang Jia were better because of the use of contour cultivation, straw and polythene mulches, intercropping and other improved agricultural technologies. Large areas in Lai Zi were under traditional farming systems. Farmers also perceived that the use of grass strips was one of the reasons for better environmental conditions in Wang Jia.

e. Crop performance and productivity

Farmers considered the cultivated area, crop vigour and estimated crop productivity to compare crop performance and productivity within the two catchments. Farmers noted the cultivated area in Wang Jia to be greater than in Lai Zi. Similarly, farmers reported that crop performance was better in Wang Jia. The height of the maize crop was more homogeneous and stems were thicker and more robust in Wang Jia, while performance of maize was heterogeneous with thin stems and weak plants in Lai Zi.

Several questions were posed to participating farmers: how different were the environmental conditions of Wang Jia and Lai Zi catchments before the Project implementation? To what extent did Project activities contribute to Wang Jia having better environmental conditions than Lai Zi? Farmers said that environmental conditions in Wang Jia were a little better than Lai Zi before Project intervention. However, the magnitude of difference in environmental conditions of these catchments had increased due to the Project's activities.

6.4 Discussion

6.4.1 Cultivation methods

Farmers were aware of the advantages and disadvantages of both contour and downslope cultivation practices (Tables 6.7 and 6.8). They anticipated wider adoption of contour cultivation replacing the downslope cultivation method (Table 6.5), although a considerable area in Yunnan still uses downslope cultivation. Farmers appreciated downslope cultivation because of relative ease in crop management (Tables 6.7 and 6.9). In such a situation, a sound dissemination programme is required to replace traditional downslope cultivation practice and thereby achieve wider adoption of contour cultivation (Tang Ya, 1999).

Contour cultivation is sometimes blamed for increasing lodging in sloping land. It is difficult to cover the stem and roots in the down side of the ridge, particularly where the slope angle is >10° (Wu Bo Zhi, 2002, *pers. comm.*), because of poor soil stability due to gravity fall on the sloping land. The poor support to root and stem on one side of the plant makes it vulnerable to lodging. No empirical evidence was found to support the farmers' perception, which is an area for future research.

Similarly, there was no evidence from the research to confirm the farmers' perception that contour cultivation needs more labour than downslope (Wu Bo Zhi, 2002, *pers. comm.*). However, farmers reported that production was higher in contour cultivation compared to downslope cultivation, because of soil, water and soil fertility conservation (Table 6.9). Similar results have been found in other studies (Bhatia and Choudhary, 1977; van Keer *et al.*, 1998; Gangcai Liu *et al.*, 2000; Milne, 2001; Barton *et al.*, 2004). This could be the reason why all farmers during group discussions expressed their preference for contour cultivation. Responses from medium, rich and mixed categories were similar. However, great discrepancy was found in the perception of the poor category with medium, rich and mixed categories regarding these issues (Table 6.9). Perhaps the poor category farmers were trying to be more positive while giving their responses. If so, the responses do not appear to represent their perceptions.

6.4.2 Mulching

Use of polythene mulch for the maize crop was very high in the catchment, which was because only maize was planted in the catchment during the summer season and the polythene was made available to farmers free of cost. So this figure gives a false impression, which is clear from the fact that a very small area outside the catchment under maize was mulched with polythene.

Farmers preferred to use straw as animal feed, so it was not available for mulching. Unavailability of inputs has been reported to impede the diffusion and uptake of technology (SUAS, 1990; Dakora and Keya, 1997). Either inadequate availability was not the only reason or farmers considered it unrealistic to use straw mulch extensively, for they were unwilling to increase the area under straw mulch by >25%, even if it were made available (Table 6.13). On the other hand, they were prepared to increase the land area under polythene mulch by >75%, if sufficient was made available. This is reflected in the farmers' response to the temporal change in the area under different mulching systems (Table 6.14). The problem of unavailability does not exist for polythene mulch. The polythene is easily available in the market at the right time and in the required quantities. Moreover, polythene is affordable to most farmers in China, due to Government subsidy.

6.4.3 Intercropping

Although the percentage of respondents using intercropping was higher in the PRA survey (Table 6.17) than in the household survey (Table 5.16), the percentage of land area under intercropping systems was low, as in the household survey, except in the case of the response from the medium wealth category. Further discussion revealed that the medium group also considered land where a few pumpkin or sunflower plants were grown in maize fields, when estimating the area under intercropping, while other wealth categories did not. This produced the difference in response of farmers' groups. On the other hand this also provided an opportunity to understand the system, i.e., mixing small proportions of companion crops can be found in ~50% area of the catchment, but proper intercropping with a good proportion of crops was practised only on 5-10% of the area. Farmers' responses about temporal change in the area under intercropping revealed the decreasing area under intercropping, which indicates that farmers were increasingly becoming reluctant to practice intercropping (Table 6.18). Farmers reported the competition effect between companion crops and resultant reductions in yield to be the main reasons for not practising intercropping. The Project's effort to develope improved intercropping technology was not useful, due to poor performance of soybean under maize (Wang ShuHui, 2003). Therefore, farmers experienced a greater competition effect between the companion crops and thus yield reduction. Fujisaka (1991), Ruaysoongnern (1999) and Tang Ya (1999) identified appropriateness to be one of the major conditions for the uptake of innovations. Selection and extension of crop varieties suitable for intercropping should be on the future research agenda before extending intercropping technology.

Some farmers gave more priority to maize (main crop) than the companion crops, as they were particularly concerned about the adverse effect on the productivity of maize by the companion crop. This indicates that farmers were aware of the potential benefits, but a suitable technological option is yet to be made available to them.

6.4.4 Tree planting

Farmers were positive about the tree planting accomplished by the Project, as they liked both the technology and species selected. In addition, farmers' interest in planting these trees in similar lands indicates that appropriate tree species were used in agro-forestry activity in Wang Jia. This is very important for the success of intercropping (Tonye and Titi-Nwel, 1995).

Despite this preference, they were reluctant to consider further uptake due to small land holdings, tree-crop competition and reduction in the area for crop production. This indicates that farmers give priority to field crops and want to maintain crop production. This can be understood from the fact that farmers have to wait long to obtain production from trees (~five years), which is difficult for the poorer farmers (Snapp *et al.*, 1998). Effects of planting trees on cultivated land on soil and water conservation and the socio-economic status of farming households requires further study, in order to be able to identify the most appropriate intervention for different environmental and socio-economic settings.

6.4.5 Irrigation

The poor category was prepared to provide more labour, but less cash to maintain the system, than the rich category. This is natural, as the poor section of society cannot produce as much cash as richer groups. But it is interesting to note that farmers from the medium category were willing to pay more than the rich category. Possibly farmers in the medium category were more dependent on farm income than poor and rich categories.

The medium group gave different answers to foreigners and Chinese researchers. While responding to the foreigner, they said it would be easy to maintain the irrigation system, but when they were talking to Chinese facilitators they completely changed their response. This was because of the Chinese tradition of not being critical and not giving negative comments, particularly to foreigners. This identifies a major potential difficulty for foreigners working with farming communities in China.

Farmers did not realise any changes in the cropping system of the catchment resulting from the irrigation system which they had supported so enthusiastically at the outset. This was primarily due to low use of the facility after its installation. The two reasons found to be responsible for the low use of irrigation system were:

- Project directives to farmers: The possibility of growing economically more profitable crops increased with the development of the irrigation system in the catchment. However, the SHASEA Project focused its work on evaluating and improving maize-based cropping systems. This meant there was no opportunity for growing other crops during the Project, which inhibited possible changes in cropping systems.
- 'Hidden agenda' for the farmers: Farmers thought that the economic return from the extra resources used in irrigating the field crops was none or marginal, so they were not interested in using irrigation for field crops. They demanded the system for more economically profitable options, such as tobacco or vegetables, which require irrigation, which they were planning to grow after the Project period. Thus, Project objectives were compromised due to the 'hidden agenda' of the farmers. On the other hand, this highlights the problem of poor communication between farmers and researchers.

Such problems might have been avoided if participatory approaches had been adopted by the Project team and farmers' participation could have been consolidated in planning, implementation and evaluation and dissemination of Project activities.

6.4.6 Dissemination and initial adoption/ adaptation of project technologies

Most farmers had at least some awareness about the Project and its activities. The information from the household survey revealed that the level of farmers' awareness was technology dependent (Tables 5.33 and 5.34). Large numbers of surveyed farmers were aware of some technology while only a few farmers were aware of others. The SHASEA Project played an important role in information dissemination. In addition, neighbours and relatives also appeared as important information providers in Kelang village, which highlights the relevance of farmer-to-farmer extension (Subedi and Garforth, 1996; Garforth *et al.*, 2003).

6.4.7 Environmental impact of Project activities

Farmers' methods of controlling runoff and soil loss were similar to researchers' practices and recommendations. Often farmers either adapt the technology extended by researchers to suit in their specific conditions or carry out age-old traditional practices transferred through continued perpetuation of the knowledge base over many generations. In Kelang village, use of farmers' own traditional methods for controlling runoff and soil loss was not evident during discussions. This could be due to the government approach, where farmers have to follow directives from higher authorities and farmers are trained to follow instructions. In such situations, farmers' traditional knowledge base becomes extinct as a forgotten story. The loss of this indigenous knowledge base occurs due to lack of utilisation, modification of techniques to make them suitable in different and/or changing conditions and transfer of the knowledge base to the next generation through reciting and describing in family gatherings and demonstrating it in the field or other real life situations.

The differences observed between the farmers' and the Project's approaches were mainly because of differences in the aim and scale of operations. The use of gauging and weather stations by the Project was for scientific study, while construction of the check dam was to contain a large-scale problem. The farmers identified positive changes in all aspects of natural resource management as a result of the Project activities; however, the magnitude of change perceived by farmers was greater than was possible within the Project duration of just four years. This indicates that farmers over-estimated the effect of Project activities. In such cases, farmers' responses need to be taken with some caution, particularly when quantitative information is considered. Often farmers tried to say something that they thought researchers would like to hear. This is the result of lack of training and experience in participatory approaches; as a result farmers did not appreciate the value of their responses in research and development processes.

6.4.8 Farmers' workshop for catchments evaluation

Farmers developed only primary level indicators at the beginning (before visiting the catchment), but they considered secondary level indicators as a basis for discussing most of the criteria. These secondary level indicators were not worked out while developing the initial evaluation criteria, but were realised during the discussion that followed the catchment examination. Farmers used the same secondary level indicators to evaluate and compare more than one primary level indicator. For example, number and size of the gully and landslides, presence of grasses and bushes in the gully and construction of stonewalls on the gully sides.

Overall, the farmers found that Wang Jia catchment was better protected. Particularly, they ascertained that the efforts to stop human abuse and animal pressure on forest resources, safeguard the environment and maintain the infrastructure were all better than in Lai Zi catchment. The farmers also reported the problem of co-ordination in managing and using natural resources in the catchment, particularly where control of the resources was shared by more than one village, as in the case of Lai Zi. Moreover, they reported that deforestation and forest encroachment to bring more land under cultivation was going on in Lai Zi. This indicates that farmers consider protection as key to improving the natural environment of the catchment. Deforestation, overgrazing, loss of soil fertility, and a decline in crop yield are the indicators of land degradation (Peili Shi and Wenhua Li, 1999). Wang Jia benefited from some infrastructure development, particularly the access road, irrigation system and check dams, which were lacking in Lai Zi. The farmers considered that, directly or indirectly, these infrastructures contributed to improve environmental conditions.

6.5 Conclusions

1. Farmers identified three main wealth classes among the farmers in Kelang village. According to the farmers' categorisation, 11% households in Kelang village were poor, 73% medium, and 16% rich.

2. As a result of the Project, the area under downslope cultivation is diminishing and the area under contour cultivation is increasing.

3. Downslope cultivation was considered to be easier, less time consuming and thus requiring less labour than contour cultivation. However, all participating farmers perceived that crop yield was higher under contour cultivation systems. Contour cultivation was preferred by all participating farmers across the wealth categories.

4. Polythene mulch was very popular, while the practice of straw mulch was almost non-existent. Polythene mulch was used primarily for maize in the catchment and for tobacco outside the catchment.

5. Insufficient availability appeared to be one of the reasons for low use of straw mulch. In general, farmers were less enthusiastic about increasing the area under straw mulch.

6. Traditionally, farmers practice intercropping, mixing small amounts of companion crops with the main crop. However, the Project's recommendations for improved intercropping

were not widely adopted, probably because there were no perceived advantages which sufficiently outweighed the disadvantages. The recommended technology did not appear to be suitable for the catchment.

7. Farmers liked the tree planting strategy and the species selected for planting. Despite their preferences, farmers were reluctant to adopt the technology due to small land holdings and tree-crop competition resulting in low crop yields. Farmers gave emphasis to annual crop production, in order to meet their family food requirements.

8. Use of irrigation was low in terms of both the number of users and the area irrigated. Farmers were willing to contribute to the maintenance, management and use of the irrigation system in future. However, these responses did not accord with their current practice. Farmers anticipated changes in cropping systems; in future maize would be replaced by income-generating crops, such as tobacco, vegetables, flowers and fruit trees. This indicates that farmers do not want to use extra resources in irrigating maize, but they will want to use the irrigation for more profitable crops.

9. All the farmers had some information about Project activities and status. Medium and rich categories were more aware than poor category farmers.

10. Most of the surveyed farmers had participated in the training programme(s). The Project did not implement gender- or wealth- differentiated training programmes.

11. The SHASEA Project was one of the most important information providers during the Project period in Kelang village. Farmers also received information about improved agricultural technologies from neighbours and relatives. This highlights the relevance of strengthening farmer-to-farmer extension systems.

12. Farmers perceived and anticipated high adoption of polythene mulch, contour cultivation, sweet chestnut and intercropping technologies in Wang Jia catchment.

13. Farmers' existing practices for the control of runoff and soil loss were similar to the Project's improved practice. The farmers' practices, however, relied more upon locally available resources to implement smaller actions at plot level. This was different to the

Project's approach, which used purchased materials to implement large scale activities at catchment level.

14. Farmers appreciated Project activities to increase forest resources, water resources and soil fertility and to decrease soil and water losses. They presented a range of different reasons for the change in the environmental conditions of the catchment, which indicated that they were aware of the benefit of Project activities. However, the magnitude of change perceived by farmers was unrealistically high.

15. Farmers were capable of developing and using their own indicators to evaluate and compare catchments with respect to environmental impacts. They concluded that the environmental condition of Wang Jia catchment was better compared to the adjacent Lai Zi catchment. The overall responses of the farmers focused on five major aspects, viz: a) current levels of soil and water loss, b) vegetation cover and natural resources, c) infrastructures and catchment management, d) use of environmentally-friendly technologies, and e) crop performance and productivity.

Chapter 7: Discussion with stakeholders

7.1 Introduction

Important issues relating to the SHASEA Project, particularly technological and development interventions and their impact on the socio-economic situation of the farmers and the environmental condition of the catchment, were discussed with various stakeholders (leading farmers, local merchants, researchers, extension agents, policy makers and YAU staff). One aim of the discussions was to study perceptions about Project accomplishments from the perspectives of these different stakeholders. Another aim was to provide further information to support the validation of the information received from household surveys and group discussions.

7.2 Methodology

The discussion was based partly on a checklist prepared prior to each meeting and partly on the stakeholders' responses. The discussion was held with individuals and in groups depending on the availability of the key informant's time (Plate 7.1). For the Key Informant Survey (KIS), ten leading farmers were selected on the basis of their knowledge and expertise on particular aspects of farming systems. Farmers who had comparatively better knowledge and experiences about the subject matter were selected to discuss the issues. The criteria for selection of the informants were discussed with village leaders. The information about leading farmers was provided by village leaders. The village leaders, extension agents, researchers and policy makers were selected for discussion according to their position and/or their involvement in the Project activities.

Plate 7.1 Discussion with extension officials in Kedu Township and Key Informants in Kelang village in Yunnan Province, 2002-03. (Source: Author)

Discussions with Chinese stakeholders (except Project researchers) were carried out with translation assistance from the Project researchers at YAU. The discussions were held during 2002 and 2003 (Table 7.1).

Table 7.1. Detail of discussions with different stakeholders during 2002-2003, Yunnan, China.

Person involved	**Institution**	**Subject discussed**	**Year**
Director of Studies	Yunnan Agricultural University	Various	2002 and 2003
Project researcher (Soil science)	Yunnan Agricultural University	Various	2002
Project researcher (Socio-economist)	Yunnan Agricultural University	Various	2002 and 2003
Professor of Horticulture	Department of Horticulture, Yunnan Agricultural University	Growth, production behaviour, and economic analysis of trees	2002
Director	Yunnan Beef Cattle and Pasture Research Centre, Xiaoshao, Yunnan Province	Various	2002 and 2003
Head	Forestry Department, Kedu Township, Xundian County, Yunnan Province	Growth, production behaviour, and economic analysis of trees	2002 and 2003
Agronomist	Agricultural Sciences Department, Kedu Township, Xundian County, Yunnan Province	Comparative profitability of trees compared to crops	2002
Soil Scientist	Irrigation and Soil-water Conservation Department, Kedu Township, Yunnan Province	Effects of pine, prickly ash and sweet chestnut trees on soil and water movement	2002
Village official/Key Informant 1	Kelang Village, Yunnan Province	Various	2002 and 2003
Village official/Key Informant 2	Kelang Village, Yunnan Province	Various	2002 and 2003
Care-taker of Wang Jia Catchment	Kelang Village, Yunnan Province	Various	2002
Merchant 1	Kelang Village, Yunnan Province	Buying and selling of used polythene	2002
Merchant 2	Kelang Village, Yunnan Province	Buying and selling of used polythene	2002
Farmer 1	Kelang Village, Yunnan Province	Economic analysis of mulching	2002
Farmer 2	Kelang Village, Yunnan Province	Economic analysis of mulching	2002
Farmer 3	Kelang Village, Yunnan Province	Economic analysis of intercropping	2002
Farmer 4	Kelang Village, Yunnan Province	Economic analyses of tree planting	2002 and 2003
Farmer 5	Kelang Village, Yunnan Province	Economic analyses of tree planting	2002 and 2003
Farmer 6	Kelang Village, Yunnan Province	Economic analyses of tree planting	2002
Farmer 7	Kelang Village, Yunnan Province	Economic analyses of tree planting	2002
Farmer 8	Kelang Village, Yunnan Province	Tree planting	2003
Project partner 1	Gembloux Agricultural University, Belgium	Geomorphology of Wang Jia Catchment	2002

Person involved	Institution	Subject discussed	Year
Project Partner 2	Gembloux Agricultural University, Belgium	Geomorphology of Wang Jia Catchment	2002
Representative of funding agency	European Union, Brussels, Belgium	Funding strategy of EU	2002
Head (Leader)	Kedu Township, Yunnan Province	Usefulness of Project technologies and uptake of Project technologies by extension system	2003
Head	Agricultural Extension Dept., Kedu Township, Yunnan Province	Usefulness of Project technologies and uptake of Project technologies by extension system	2003
Technician	Agricultural Extension Dept., Kedu Township, Yunnan Province	Uptake of Project technologies by extension system	2003
Head (Leader)	Kelang Village, Yunnan Province	Usefulness of Project technologies	2003
Manager	Soil and Water Conservation, Yunnan Provincial Bureau of Hydrology and Water Conservancy, Kunming, Yunnan Province	Policy issues	2003

7.3 Results

The discussions with different stakeholders were based on Project technologies, exploring additional and complementary explanations for the information collected from household surveys and group discussions.

7.3.1 Cultivation method

Comparative advantages of downslope and contour cultivation were discussed with some Key Informants of the village. The discussion focused on two broad issues, viz. (a) ease of operation and (b) their effect on soil-water conservation and crop production.

7.3.1.1 Ease of operation

Intercultural operations are particularly easy in downslope cultivation. In contour cultivation, weed control, earthing up and covering the polythene on the downslope side are difficult.

- *Tillage and sowing:* Contour cultivation was considered easier, because in downslope cultivation farmers have to walk up and down the slope, which is more difficult compared to walking straight at the same height on the contour. This response was in contrast to the farmers' response during the group exercises (Table 6.7) and so the Key Informants were prompted for further explanation. The Key Informants said that cultivation (first time digging for sowing a crop) in the catchment is done manually without following either downslope or contour cultivation. Subsequent planting is then done downslope or on the contour.

- *Irrigation:* It was considered to be easier and more effective in contour cultivation. The irrigated water is retained in the field by the ridges along the contour, which facilitates infiltration. In downslope cultivation, the irrigated water quickly runs down to the bottom of the slope allowing less time for infiltration and leading to soil and nutrient losses (Rodriguez and Fernandez de la Paz, 1992; van Keer *et al.*, 1998; Barton, 2000; Milne, 2001).

- *Weed Control:* Respondents considered that weed control in contour cultivation was not as easy as in downslope cultivation, particularly controlling the weeds on the downslope side of contour ridges.

- *Earthing-up:* It was perceived to be easier and more effective in downslope cultivation. In contour cultivation earthing-up of the downslope side of the ridge is difficult. There is typically less soil in the downslope side of the ridge, as a result covering of roots and supporting the stem is not as effective as in downslope cultivation.

- *Fertilisation:* It was considered to be more effective in contour cultivation. The losses of fertilisers applied are higher on downslope cultivation, particularly during rainy periods.

- *Mulching with polythene:* It was perceived to be easier in downslope cultivation. Both sides of the ridge can be covered well in downslope cultivation, while it is difficult to cover the downslope side of the ridge in contour cultivation.

- *Water drainage:* Downslope cultivation was considered to be more effective in draining excess water. In continuous and prolonged rainfall conditions, the water is retained by contour ridges and can cause waterlogging, which is harmful to maize and tobacco.

- *Harvesting:* Contour cultivation was considered to be easier for harvesting the crop. There is no need to walk up and down with the harvested load, as in the case of downslope cultivation.

In summary, Key Informants in the village perceived contour cultivation to be easier than downslope cultivation for irrigation, fertilisation and harvesting, while downslope cultivation was perceived as easier than contour cultivation for weed control, earthing-up, covering polythene and draining excess water.

7.3.1.2 Effects on soil and water conservation and crop production

The effects of two cultivation practices (downslope and contour cultivation) on various aspects of soil and water conservation and crop production were discussed with farmers.

- *Soil, water and nutrient losses:* The rate of runoff was considered to be high in downslope cultivation causing high losses of soil, water and nutrients, an observation confirmed by many published studies (Neal, 1963; Rodriguez and Fernandez de la Paz, 1992; Sombatpanit *et al.*, 1995; van Keer *et al.*, 1998; Barton, 2000; Milne, 2001). The ridges across the slope in contour cultivation reduce runoff and, as a result, more water infiltrates. The magnitude of the effect, however, depends on the amount, intensity and duration of rainfall.

- *Soil fertility:* Soil fertility was considered to be similar in contour cultivation and downslope cultivation methods before the rainy season. However, after the rainy season, the fertility status of the soil was higher in contour cultivation than downslope cultivation, because of increased soil loss and leaching.

- *Soil organic matter:* Soil organic matter (SOM) was considered to be similar in contour and downslope cultivation before the rainy season. In addition, there was a perception that SOM remains higher in fields where contour cultivation has been practised in previous years than fields where downslope cultivation was practised in the past. After the rainy season SOM may be higher in contour cultivation, because the light fertile soil particles are more likely to be lost through runoff.

- *Soil colour:* Generally soil colour was considered to be darker in contour cultivation and lighter in downslope cultivation, but this also depends on the amount of manure applied in the field and the amount of soil loss.

- *Yield:* Yield was considered to be higher in contour cultivation, an opinion supported in the literature by Bhatia and Choudhary (1977), Fullen *et al.* (1996) and Wang ShuHui (2003). Again the amount of runoff (soil, water and nutrient losses) appeared to dictate the difference. However, in the case of heavy rainfall, water stagnates on the upper side of the ridge, which poses the threat of waterlogging. Waterlogging is inimical for both maize and tobacco, so under high rainfall situations, the yield difference may not be great, even though soil, water and nutrient losses are greater in downslope cultivation.

- *Yield of the following crop:* The yield of the following (winter) crop was considered to be greater where contour cultivation was practised during the previous (summer) season, because of improved soil and water conservation. In the winter season, farmers did not practice either method (wheat, the dominant crop is sown by broadcasting) and so there was no definite pattern of dispersal.

In summary, contour cultivation was considered by the Key Informants to improve soil and water conservation, associated with an increase in yield.

According to the Key Informants, Wang Jia catchment generally received at least two major storms per year leading to significant soil, water and nutrient losses. In addition to the above-mentioned advantages and disadvantages, farmers considered the following issues when selecting the cultivation method:

- If the slope is very steep downslope cultivation is used, as it is particularly difficult to make and maintain contour ridges and carry out intercultural operations at greater slope angles.
- Smaller slope angles – more likely to use contour cultivation.
- If tobacco – use downslope cultivation.
- If vegetables – use downslope cultivation.
- If the terrace length is long but width is narrow, then use contour cultivation.
- If the terrace length is short but width is wide, then use downslope cultivation.
- If both length and width of the terrace are extensive, then there is a choice of contour or downslope cultivation depending upon the farmer’s personal preference.

7.3.2 Mulching

The Key Informants of the village thought that all wealth categories preferred polythene mulch technology, making widespread adoption more likely. However, the survey results indicated that adoption might be lower in the poor wealth category compared to rich and medium categories, because of the cost of polythene.

In contrast, there is a strong disinclination towards adoption of straw mulch technology, so its adoption would be unlikely for all wealth categories. Farmers understand the benefits of straw mulching, but they prefer to use any available straw for other purposes, including animal feed and bedding.

Discussions with the Project researchers revealed that polythene mulch technology had been extended to farmers since the early 1980s (1983-84) by the Provincial Government of Yunnan (Wu Bo Zhi, 2002, *pers. comm.*). This technology had been recommended for the central and North highland areas of Yunnan, where temperatures remain lower than required for optimum crop growth. This technology was initially extended to increase the productivity of summer crops, but later farmers adapted it for winter crops, particularly for vegetables, winter maize and winter tobacco. This adaptation followed the realisation of the benefits in alleviating the problem of low temperatures and moisture stress during winter. The highland areas of Yunnan experience acute moisture stress, particularly during winter. The Government provides substantial subsidies (paying considerable funds to polythene industries) to encourage the use of polythene mulching technology. At present, the cost of polythene is 10 Yuan/kg (£ 0.80/kg), about half the full cost.

In an effort to control environmental pollution from the polythene, the Chinese Government has made a general recommendation to farmers to collect polythene from the field after use (BBC, 1997; Shenzhen Daily, 2001; China Internet Information Center, 2002). Some farmers were recovering the used polythene from the field, cleaning and selling it to local merchants in Kelang village. Further discussions were carried out with two of these merchants (Box 7.1).

7.3.3 Intercropping

Discussion with Key Informants revealed that French bean was a more popular companion crop for maize in Wang Jia, probably explaining the poor adoption of the recommended maize-soybean system.

7.3.4 Tree planting

The process and basis of selecting tree species was discussed with Project researchers. Sweet chestnut and prickly ash were planted in farmers' fields, while pine was planted in forest (Government) land. Climate and soil in Kedu is suitable for sweet chestnut. Moreover, the quality of sweet chestnut produced in the Kedu area was very good. The Township also wanted to increase sweet chestnut production to promote export. Therefore sweet chestnut was planted in the lower region of the catchment, but temperatures were too low for growing sweet chestnut

Box 7.1 Discussion with two women of Kelang village who recycled polythene.

Merchant-1:

She had been running this business for the last three years. Her annual transaction was about 10,000 kg of used polythene. She was not selling new polythene for mulching. She is exclusively involved in recycling, which indicates that polythene recycling is a lucrative business in the village. After buying from the farmers, she used to sell the used polythene to the broker merchant in Kunming City, who finally sold to the factory.

She was buying the used polythene from the farmers for 1.2 Yuan/kg and selling to the broker merchant for 1.3-1.4 Yuan/kg. That means her total income from recycling 10,000 kg used polythene is 10000 kg x 0.1-0.2 Yuan/kg = 1000 – 2000 Yuan per year (80-160 £/year).

This merchant was mainly recycling the polythene used for tobacco. The polythene used in maize is mixed with sticky soil due to trampling during various operations in the rainy season. Such polythene is difficult to collect and clean. The used polythene needs to be fairly clean to be acceptable for recycling, which limits the usefulness of maize polythene.

Merchant-2:

She had been doing this business for five years. She was selling new polythene to farmers for mulching and bought used polythene from farmers. Her annual transaction was about 3,500 kg of used polythene. The buying rate (from farmers) of used polythene was 1 Yuan/kg and the selling rate (to plastic factory) was 1.3 Yuan/kg. She was selling the used polythene to the polythene factory in Kunming City.

This merchant was also recycling the polythene mainly from tobacco production. About 97% of polythene she was recycling was from tobacco, while only 3% was from maize fields.

in the upper catchment. Prickly ash was considered a more appropriate species for the upper slopes. Prickly ash is widely used for spices and has a high market price (9 Yuan/kg). Soil quality in the upper catchment (forestland) was considered poor, but pine trees were already established in that area. However, the tree population was unevenly and sparsely distributed. Therefore pine was chosen for gap filling in the existing pine forest and plantations were established in areas where there were no trees. Selection of species was made by YAU researchers, township/village leaders and some farmers. Not all farmers whose land has been used for planting trees were involved in selecting the species or in the decision-making process.

Land selection was based on slope. Land with >25° slopes was considered for planting, which accords with government policy to convert agricultural land on slopes >25° into forestland (Tang Ya *et al.*, 2003; Zhu Xioke, 2003, *pers. comm.;* Shi *et al.*, 2004). Farmers were notified about the decision later. Consequently farmers had mixed views about the researchers' and leaders' decisions.

The plantation area was managed jointly by the Project and village leaders. At the beginning, seedlings, labour for planting and other inputs were provided by the Project. After that, management of the growing plants (weeding, manuring, irrigation, replanting/gap filling) was also done by the Project. These works were completed by hired labourers. The landholders did not provide any labour support (paid or unpaid). There is a possibility that landholders were not requested for any contributions. Therefore, plot owners did nothing to the plants during the Project period, but responsibility was transferred to them on the completion of the Project.

Likely adoption of tree planting technology by different wealth groups was discussed with the Key Informants of the village. They thought that trees did not provide quick returns. Therefore the adoption of trees would be more likely among the richer farmers (rich and some medium categories who have good economic buffering capacity) and could wait until the trees started to produce at their full potential.

Further discussions with farmers and Key Informants also revealed the need for extension and training about improved management for tree planting (Box 7.2).

Box 7.2 A tree farmer of Mosu village

Mr. Ma Liang Shun, a resident of Mosu Village (1 km east of Kelang village) was running a restaurant in Kelang village market. He had rented-out some of his land to other farmers, as he was busy in the restaurant business. He was receiving either 100 kg hulled rice/mu/year (1500 kg hulled rice/ha/year) or 70-80 Yuan/mu/year (1050-1200 Yuan/ha/year) as rent for the land. The rate was based on land quality. This rate of rent was for average quality land. He had planted 500 sweet chestnut plants in ~6 mu (4000 m^2) land area. This density (83 plants/mu or 1245 plants/ha) was 3 times higher than the recommended density (27 plants/mu or 405 plants/ha). He had planted the trees four years ago. He said that the tree canopy started to close and was thinking about removing the trees, which were performing poorly. He had not sought information about the optimum density of sweet chestnut before planting the trees.

It appears this farmer lacked information about the improved technology for tree planting. This was not the only case, as another farmer (Mr Yang Xingbang from Kelang village) was also found to plant prickly ash at a very high density. This reveals the need for extension and training support for farmers, which is essential to achieve wider adoption/adaptation of Project technologies

7.3.5 Irrigation system

Some issues related to the irrigation system were discussed with Project researchers. The irrigation scheme was targeted for 10-13 ha, out of the 27.3 ha of total cultivated area of the catchment. The water was sufficient for this area, if used on a rotational basis.

There were not any major changes in the cropping system following the introduction of irrigation in the catchment. The Project was focused on increasing the productivity of maize and wheat in the upland areas. The main impact intended by the Project team was to increase the extent of winter cropping with wheat and improve the reliability of maize establishment in the spring. Therefore the scope for change was limited.

The post-Project management and use of the irrigation system was a major concern and so management issues were discussed with Project researchers. During the Project period, maintenance was required mainly for replacing broken pipes and gate valves, and controlling pond leakage. About 2000 Yuan/year was sufficient for maintenance. Usually two maintenance sessions per year were sufficient, except in the case of severe damage due to landslides and sediment deposition in the pond due to flooding. This level of maintenance should not be any problem for the village office once the irrigation system had been handed over to the village upon Project completion. The system was new during the Project period, so the maintenance cost was relatively low; however, this could increase when the system became older. Under such a situation, it could be difficult for them to maintain the system if the cost increased greatly.

The use of the irrigation system was less than capacity. The irrigation system was constructed as per the proposal of the Township, so the low use was surprising. The issue was discussed with Key Informants and Project researchers and the following facts were revealed:

a. Farmers rated paddy land as important, not upland. So they did not want to invest extra resources/efforts on uplands.
b. Farmers thought irrigation was not important for winter crops.
c. Farmers whose land was far from the pond did not use it.
d. During 2001 and 2002, the rainy season started early. Due to this, there was no urgent need for irrigation.

The Key Informants confirmed the farmers' intention to grow tobacco in the catchment after the Project period. Cultivation of tobacco requires irrigation, so the irrigation system was actually requested for tobacco cultivation. A Key Informant thought that tobacco would be planted in about 50% of the catchment area. When asked ‘why not 100%?’, he replied that tobacco requires more labour, so the area probably would not exceed 50%.

Farmers in upland areas of Yunnan use difficult and costly methods of irrigation, which are not always cost effective, particularly in the case of field crops. It is not possible to use surface irrigation in the rugged sloping upland areas of Yunnan. Therefore farmers use polythene pipes to irrigate fields, which is relatively costly if the land is far from a pond. Polythene pipe is used on sloping land and irrigation channels on flat land, but if the land is at higher elevations than the pond or it is difficult to irrigate the field with pipes, then they carry the water on their shoulder, which is labour intensive and costly. The effect of irrigation on the overall productivity of field crops could not be studied due to the very low use of the irrigation system. The results of a controlled experiment carried out in the catchment showed that irrigation could substantially increase maize yield (Huang BiZhi, 2001).

7.4 Environmental impact of Project activities

Change in environmental conditions is a slow process, and it is difficult to identify the differences in the environmental condition of the area within short periods of time. So, an indicative impact of Project activities was discussed with Project researchers.

Change in soil organic matter (SOM) is one of the indicators of sustainability of the area. There was a slight increase in the SOM status of the catchment (Li YongMei, 2004) (Table 7.2). However, Project researchers perceived that it was difficult to conclude that the increase was because of Project activities, as four years was insufficient to achieve significant changes in SOM.

Table 7.2 Soil organic matter content of soil of Wang Jia catchment during 1999-2002.

Year	**Soil OM content (%)**
1999	2.18
2001	2.57
2002	2.64

(Source: Li Yongmei, 2004)

Rates of manure and fertiliser application were less than official recommendations, the rate of organic manure application for maize was 15 t/ha. Farmers generally used a limited amount of organic manure, particularly to the annual crops in the catchment before the Project intervention. There was no access road in the past, which meant labour costs for carrying organic manure were very high. As the income from the catchment was low, the cost of using the input was higher than its benefits. Construction of an access road in the catchment by the Project partly alleviated this problem, while training and suggestions from researchers also encouraged farmers to use more organic manure.

Regarding erosion and siltation in the catchment, the Project researchers said that a systematic study had not been made to study the changes in erosion processes. However, it had been realised from general observations that the frequency of occurrence and size of landslides had decreased. The sediment losses from the catchment had been monitored through the hydrology station and found to be significantly reduced. These changes were mainly because:

- Grazing had been prohibited in the catchment, due to which vegetative cover increased.
- Expansion of gullies had been checked and flooding reduced, due to the construction of check dams. The check dams appeared to have been effective in reducing the velocity and erosivity of runoff.
- The Project encouraged farmers to use contour cultivation, which had helped conserve soil and reduce runoff.

Downstream effects of agricultural activity in the catchment were discussed with the Project researchers. Although it was not studied systematically, some favourable changes had been noticed, for example:

- Before the Project, gullies had been expanding, and some houses near to one of main gullies were moved as a result of the danger posed. The gully was stabilised by the construction of check dams and the danger was reduced. Farmers and the Township Office always mentioned this as an example of improvement. This was more important for them than the increased productivity.
- After the building of check dams in 2000, the depth of one of the main gullies decreased due to deposition of sediments on the upside of the check-dam. Farmers planted trees on the deposited sediment (inside the waterways), which helped in gully stabilisation.
- Flooding and sediment loss was very high before implementation of the Project and had been significantly reduced. The amount and velocity of runoff was considerably reduced.

- Floods from the catchment had previously damaged crops in the paddy fields below the village by washing off and depositing eroded sediments. Such damage had been reduced after Project intervention.

7.5 Dissemination and initial adoption/adaptation of Project technologies

7.5.1 Methods of dissemination

Project researchers outlined that they had undertaken the following activities for the dissemination of research outcomes:

7.5.1.1 Sharing Project outcomes in meetings/workshops

One meeting was organised during the first year of the Project to introduce and disseminate Project activities. During 2001, a workshop was organised for the farmers of Kelang Village, technicians from different villages and experts from Xun Dian County. The workshop was organised in Kelang village and its purpose was to disseminate Project technologies. Similarly, a SHASEA workshop was organised at YAU in 2002 to disseminate Project technologies and discuss the problems related to adoption. This workshop was organised for provincial level leaders and experts.

7.5.1.2 Increasing farmers' awareness through training

Training was conducted on Project technologies for the farmers of Wang Jia catchment. The training was on Project technology, including contour cultivation, planting in single/double ridges, ridge spacing, mulching technologies and planting techniques for wheat.

7.5.1.3 Material help/compensation to encourage initial adoption

Seeds of maize and wheat and polythene were provided free to farmers of Wang Jia catchment, in order to promote adoption of Project technologies. This activity was continued for three years from 2000 to 2002; it was limited during 2000/2001 but these production inputs were distributed extensively in Wang Jia catchment during 2002. Maize variety Dian Feng 4 was distributed for the middle and lower part of the catchment, while Hui Dan 4 was used for the upper catchment. Details are shown in Table 7.3. Polythene was provided for the farmers and distribution was limited to land with gentle slopes only, to avoid the risk of the negative consequences of substantial runoff from steep slopes. Seedlings and subsequent management of the trees were provided for those farmers who planted trees on their land. In addition, during 2002 financial compensation was given to farmers at the rate of 1050 Yuan/ha to compensate for the additional labour required to adopt Project technologies, particularly contour cultivation and polythene mulch.

Table 7.3 Details of free inputs and compensation provided by the Project to the farmers of Wang Jia catchment during 2000-2002, discussion with stakeholders, Yunnan, China, Summer 2003.

Type of subsidy	**Year**		
	2000	**2001**	**2002**
Polythene			3 kg/mu (45 kg/ha)
Maize seed		2 kg/mu (30 kg/ha)	2 kg/mu (30 kg/ha)
Wheat seed	150 kg for about 10 mu (~ 0.7 ha)	800 kg for about 70 mu (~ 4.7 ha)	
Labour compensation for using contour cultivation and polythene mulch			70 Yuan/mu (1050 Yuan/ha)
Tree planting	All costs	All costs	All costs

(Note: 1 ha = 15 mu, 1 GBP = ~12 Yuan).

7.5.2 Training programme of the Project

Discussion on the training programme of the Project was focussed on the following two issues:

7.5.2.1 Farmer participation in the training programme

According to Key Informants, the training programme focused mainly on those farmers who had one of the 100-monitoring plots. In addition, all 115 households in Kelang village who had land in Wang Jia, were also involved in the training programmes. The Project did not have a gender-oriented or differentiated training programme. Female participation was spontaneous, without any efforts from the Project to consolidate their participation. Similarly, there was no user-differentiated training. All farmers in the catchment were included in the training programme, but farmers from outside the Project catchment area were not involved. Kedu Township organised a training programme in Wang Jia catchment during 2000 about Project technologies for all village leaders of Kedu Township.

7.5.2.2 Effectiveness of the training programme

Farmers used the Project technologies they learned in the training programme, but the extent of use varied. Key Informants estimated that ~60% farmers used the Project technologies ‘very well’, ~30% used it ‘well’ and ~10% ‘to some extent’.

7.5.3 Participation and views of extension agents

Six extension experts from different departments of Kedu Township participated in Project activities. They were particularly involved in designing and constructing the irrigation system and check dams, providing expert advice on tree planting activity and organising training workshops. In addition, their expertise was used to disseminate Project technologies. In 2002, some technicians from the Agricultural Extension Bureau of Kedu Township stayed in Kelang village for two weeks, to facilitate initial use of Project technologies by farmers.

The issue of whether extension agents included the Project technologies in their work programme for extension in larger areas was discussed with Project researchers. This proxy-indicator was used to study the level of communication and linkage between research and development institutions and uptake of Project technologies by extension agents. It was assumed that Project researchers would notice significant uptake of Project technologies by extension systems, and Project researchers would be aware of the situation, if the communication and linkage between research and development institutions was strong. However, Project researchers were unsure whether extension agents included Project technologies in their work programme for extension in the larger areas or not. This indicates that significant uptake of Project technologies by extension agents for wider dissemination is yet to happen. In addition, it also points out the inadequate communication between research and development institutions.

7.5.4 Perceptions of policy makers

The role of authorities at provincial level is very important in facilitating the wider dissemination of technology. They play a key role in formulating policies and programmes at provincial level. Therefore discussions were held with the Manager of the Soil and Water Conservation Bureau of Yunnan. The aim of the discussion was to study her awareness and perception of Project technologies with the assumption that it is necessary to bring the Project output to her attention to facilitate and achieve wider dissemination.

The Manager had some knowledge about the SHASEA Project, but did not have detailed information. She found similarities in regional priorities for China for soil and water conservation and the objectives of the SHASEA Project. In addition, the policy maker appreciated that the Project was addressing the regional policy for soil and water conservation. Moreover, some policy adjustment and changes in working approaches have been made after consideration of the Project outcomes. For example, in the past, research and development projects were prepared on the basis of desk review of available information and maps. After 2001, the authorities started to consult local people and visit possible project locations before designing projects. In one of the project planning meeting with farmers, the authorities had asked farmers how much labour they could provide for the project. In this way, farmer participatory approaches were being increased in the working approach of the government.

In general, the interaction between Provincial policy makers and the Project team was low, as they did not visit the Project location or participate in any of the Project activities, except the final conference (SASEA Workshop) (SHASEA, 2002b). However, they were considering Wang Jia catchment as a model site for red soil areas, as detailed study had been done in this catchment. The Manager praised the holistic and multidisciplinary approaches adopted by the Project to tackle the problems identified. The approach to collaborate between local implementer (YAU), local government (Kedu Township) and local farmers in Project activities, such as in planning the irrigation system, selecting trees and constructing the check dam, was appreciated by the Manager. She thought that the evaluation of the Project was a very good idea, no matter whether the Project outcomes were good or poor. However, she was of the opinion that management of the catchment after the Project needed to be considered, particularly if some of the activities were incomplete and needed further attention.

The Manager responded positively to the use of Project outcomes in wider areas. The County Government was already using contour cultivation and polythene mulch technologies and considering the adoption of grass strips and straw mulch technologies in the future. Adoption of contour cultivation technology in large areas requires full involvement of the farmers, along with training on the technology. This programme required a strong component of farmer training activities and the County Government was going to allocate financial resources required for the implementation of these activities.

7.6 Conclusions

1. Key Informants of Kelang village perceived contour cultivation to be easier than downslope cultivation for irrigation, fertilisation and harvesting, while downslope cultivation was perceived as easier than contour cultivation for weed control, earthing up, covering polythene and draining excess water.

2. Key Informants perceived that contour cultivation had more favourable effects on production compared to downslope cultivation. Soil, water and nutrient losses were greater in downslope cultivation resulting in inferior crop performance. In contrast, better retention of soil moisture and soil fertility, and higher crop yields were perceived to be the effects of contour cultivation. High weed populations were the only disadvantage of contour cultivation.

3. Polythene mulch was a preferred technology, although its adoption could be limited among poor categories of farmers, because of the cost involved in purchasing polythene.

4. Collecting the polythene mainly used for tobacco and selling it to local merchants was being carried out by some farmers in Kelang village. Only a small proportion of polythene used for maize was recycled, due to difficulties in collecting the polythene from the field and cleaning it.

5. Straw mulch was not popular in Wang Jia catchment because of poor availability of straw and large cost requirements, particularly if straw had to be purchased or transported from elsewhere.

6. The soybean variety evaluated by the Project for intercropping systems did not appear to be suitable for Wang Jia catchment.

7. Tree planting activity was recognised as complying with Government policy and at the same time taking advantage of the export potential of the products. Land with >25° slope angle was selected for planting, in accordance with Government policy.

8. Key Informants perceived that trees did not provide quick returns, so adoption would be more likely among the richer farmers who have good economic buffering capacity and can wait until the trees start to produce at least as much income as traditional crops.

9. All the decisions regarding planting area and tree species were taken by the Project researchers and leaders of the Township and village. Farmers were not involved in the decision-making process, which may have limited their commitment to the tree planting scheme.

10. The Project focused on increasing the productivity of existing maize- and wheat-based cropping systems in the catchment, so within the period of the Project, there were not any major changes in the cropping system due to the installation of irrigation in the catchment.

11. The use of irrigation in the catchment was less than the capacity of the irrigation system. From discussion with Key Informants, it became apparent that farmers were considering growing tobacco in the catchment after the Project period, for which they were planning to use the irrigation system.

12. Some favourable indicative effects of Project activities on environmental conditions in the catchment and on downstream areas were identified by the villagers. For example, increases in organic manure application, reductions in the occurrence and size of landslides in the catchment and less destruction of village houses and downstream agricultural land by flooding in the gully.

13. Project outcomes were disseminated through sharing information with local leaders and technicians in meetings/workshops, by increasing farmers' awareness through training and by providing material help/compensation to encourage initial adoption. The dissemination of Project activities was limited to the catchment only, as wider dissemination outside the catchment had not been planned.

14. There was inadequate communication between Project researchers and local extension officers regarding the dissemination of Project technologies, particularly for extension outside the catchment.

15. There was inadequate communication between Project officials and policy makers at Provincial level and thus the latter had only limited information about the Project. After a general briefing, the provincial officer appreciated the Project processes (such as multidisciplinary and holistic approaches, involving farmers in project activities), technologies and application of scientific approaches (such as the gauging station) to tackle the problem of soil and water erosion in the region. Perhaps wider dissemination of project technologies through Government extension networks and policy decisions would have been easier if the Project had established regular communication with such decision-making bodies.

Chapter 8. Field survey, direct observation and economic analysis

In addition to the responses from different stakeholders, the outcomes from the SHASEA Project were evaluated by four studies involving direct observations and analyses:

1. plot survey,
2. tree survey,
3. diagnostic erosion survey (DES),
4. economic analysis.

A second purpose of these studies was to generate information for the triangulation of household responses and the perceptions of village stakeholders collected using different participatory techniques. The catchment and surrounding areas were visited many times and direct observations made in order to monitor the cropping practices used, the environmental changes in the catchment and the socio-economic situations of farmers. The responses received previously from different sources and methods were checked and verified during this observation phase.

8.1 The '100 plot' survey

8.1.1 Introduction

The 100 monitoring plots were selected by the Project team to represent physical and biological diversity in the catchment (Fig 8.1.1). These plots were used to study the changes in crop productivity in the catchment during the project period. The results of the '100 plots' survey carried out by Project researchers during the Project period have been summarised in Chapter 4. An additional study was conducted at the end (Summer 2002) and immediately after the project completion (Summer 2003) to evaluate the uptake of project technologies in the same plots. This section presents the results of this additional study.

8.1.2 Methodology

To produce 100 plots for monitoring purposes, 10 farmers' plots were identified randomly within 10 'windows' selected to represent the physical and biological diversity within the catchment. From the original 100 plots, 97 were in use in 2002 and the cropping practices in all these plots were studied. In 2003, 96 plots were evaluated. In both years, the following were observed:

- Crop/variety cultivated
- Crop performance: the performance of crops was observed and classified into one of three categories: good (dark green colour, good vigour, strong stem, large cobs), fair

(green colour, not vigorous but not weak either, most of the plants bearing cobs but cob size not large) and poor (pale green colour, thin and weak stem, some lodging, small cobs, barren plants)

- Cultivation practices used (downslope or contour),
- Use of mulching (straw and/or polythene),
- Use of intercropping,
- Name of the crop grown under maize, if any.

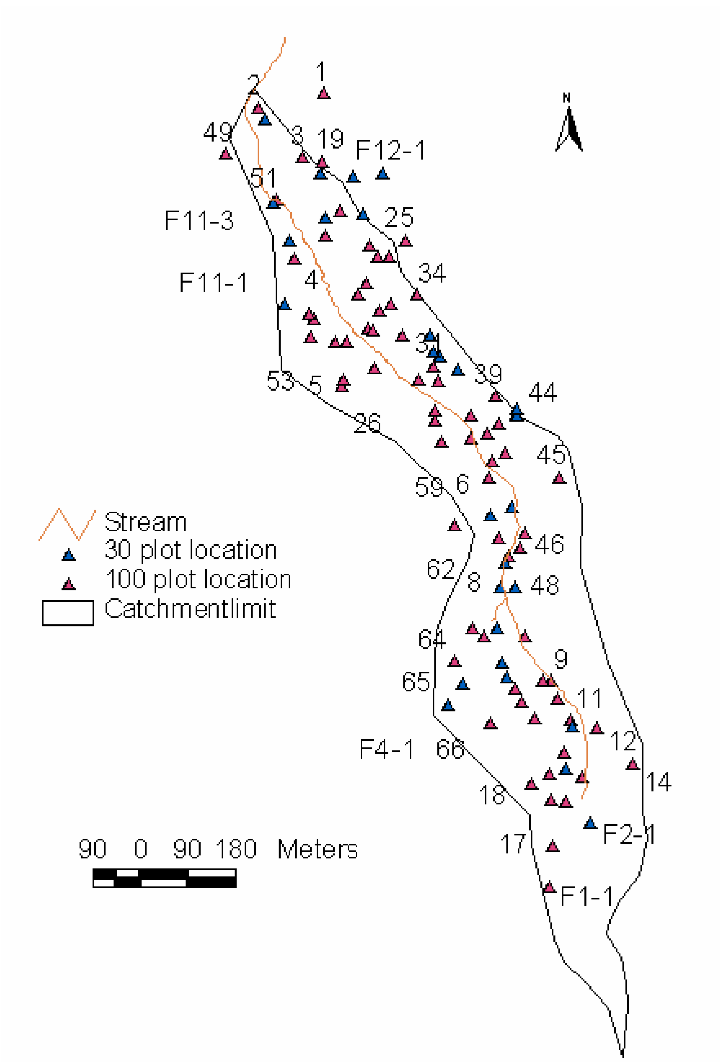

Figure 8.1.1 Location of the 100 plots in Wang Jia catchment (Source: Li YongMei, 2004).
(Note: The 30 plots were selected for more detailed analysis in a separate investigation)

8.1.3 Results

Maize (*Zea mays*) was the dominant crop in Wang Jia both in 2002 and 2003. Maize was grown in all of the surveyed plots in 2002 while other crops were grown in 13% of the surveyed plots in 2003 (Table 8.1). Among the other crops, tobacco (*Nicotiana tabacum*) was the next most widely grown (in 9 plots) followed by Chinese cabbage (*Brassica campestris* L.) (3 plots) and French bean (*Phaseolus vulgaris*) (1 plot). Crop performance varied between different plots, as the crop was estimated to be good in 53% of plots, while it was fair in 26% and poor in 21% (Table 8.2)

Table 8.1 Crops/ variety grown in the monitoring plots surveyed during 2002 and 2003.

Crops/variety	**Frequency**	
	2002	**2003**
Maize	97 (100%)	83 (87%)
DF 4	*63*	*34*
HD 4	*33*	*50*
Q3	*1*	-
Tobacco	-	9 (9%)
French bean	-	1 (1%)
Chinese cabbage	-	3 (3%)
Total	**97**	**96**

Table 8.2 Crop performance in the monitoring plots surveyed during 2003.

Crop performance	**Frequency**	**%**
Good	51	53
Fair	25	26
Poor	20	21
Total	**96**	**100**

Downslope cultivation was used only in ~5% of plots in 2002, increasing to 34% in 2003 (Table 8.3). By contrast, the contour cultivation system was used in ~97% of the plots in 2002, reducing to 64% in 2003.

Table 8.3 Use of different cultivation practices in the monitoring plots surveyed during 2002 and 2003.

Planting system	**2002**	**2003**
Downslope cultivation	3 (3%)	33 (34%)
Contour cultivation	92 (95%)	61 (64%)
Other (typically both in one plot)	2 (2%)	-
None	-	2 (2%)
Total	**97**	**96**

Use of straw mulch in maize was low and remained the same during and after the Project (Table 8.4). By contrast, the adoption of polythene mulch was high (85%) during the Project, which decreased drastically after Project completion, down to 18% in 2003 (Table 8.4).

Table 8.4 Use of mulching technologies in the monitoring plots surveyed during 2002 and 2003.

Mulching method used	**Number (percentage) of plots**	
	2002	**2003**
Straw mulch	1 (1%)	2 (2%)
Polythene mulch	82 (85%)	17 (18%)

Out of the 17 plots where polythene mulch was used in 2003, 8 plots were under tobacco, 7 under maize and 2 under Chinese cabbage (Table 8.5). This indicates the use of polythene mulch for the maize crop was low.

Table 8.5 Use of polythene mulch technology in different crops in the monitoring plots surveyed during 2003.

Crops	**Number of plots (% of total)**		
	Mulched	**Not mulched**	**Total**
Maize	7 (8%)	76 (92%)	83
Tobacco	8 (89%)	1 (11%)	9
Beans	0 (0%)	1 (100%)	1
Vegetables	2 (67%)	1 (33%)	3

Intercropping was used in 21% of plots in 2002 and 24% in 2003 (Table 8.6). Use of intercropping remained quite similar during and after the Project period. French bean (*Phaseolus vulgaris*) and soybean (*Glycine max)* were among the more widely used companion crops for intercropping with maize (Table 8.7).

Table 8.6 Use of intercropping technology in the monitoring plots surveyed during 2002 and 2003.

Year	**Number (%) of plots**
2002	20 (21%)
2003	23 (24%)

Table 8.7 Second crop used in intercropping with maize in the monitoring plots surveyed during 2002 and 2003.

Crop/variety	**Number of plots (% of total)**	
	2002	**2003**
French bean	14 (15%)	10 (11%)
Soybean	4 (4%)	9 (9%)
Sunflower	2 (2%)	2 (2%)
Tobacco	-	1 (1%)
Bean and flower	-	1 (1%)
Total plots under intercropping	20	23
Total plots	97	96

8.1.4 Discussion

Most plots were under maize during the Project period, while only 87% were under maize after the Project. Farmers grew only maize in the catchment during the summer season, as advised by the Project team (Wu Bo Zhi, 2002, *pers. comm.*). This indicates that the Project objective of improving maize-based cropping systems indirectly reduced crop diversity in the catchment. The areas under tobacco and vegetables may increase in the future, particularly in the lower, flat area of the catchment (refer Sections 6.3.2.5 and 7.3.5).

It was difficult to evaluate the change in the use of cultivation methods before and after Project intervention, due to the absence of baseline information. Contour cultivation was used in ~52% of the plots in 1999 (first year of Project) (Li YongMei, 2004). The adoption of contour cultivation in 2003 was ~12% more than in 1999. However, there was an informal agreement between the village office and farmers, in which farmers agreed to use the Project technologies in the upper part of the catchment and in response the village authority relaxed the ban on tobacco cultivation in the lower part. In this context, the use of contour cultivation may decrease further once farmers are allowed to make their own decisions about the use of Project technologies.

The use of polythene mulch for maize crop decreased drastically immediately after the Project. In fact, the high implementation of Project technologies in 2002 was probably because the Project team not only advised farmers to use polythene mulch for maize crops, it also provided the polythene free (Table 7.5.1.3). The use of polythene decreased along with the cessation of its free availability after the Project. The analysis of the proportionate area under polythene mulch revealed that a low percentage of maize but a high percentage of tobacco and vegetable areas were mulched with polythene. This suggests that farmers were yet to be convinced that polythene mulch was economically profitable for maize, while they believed it was for tobacco and vegetable crops. Again, it was difficult to compare the current level of use of polythene mulch in the catchment with that before Project intervention. In 1999 (the first year of the Project), polythene mulch was used in 17 plots (Li YongMei, 2004), which was exactly the same as in 2003.

The use of intercropping in 1999 (46 plots) (Li YongMei, 2004) was higher than in 2002 and 2003. The reason behind the decrease in area under intercropping was not apparent during the plot study. Poor performance of soybean under maize (Wang ShuHui, 2003) could be the reason for the farmers' reluctance to use the intercropping practice advocated by the Project team.

8.1.5 Conclusions

1. It was difficult to evaluate the change in the use of cultivation methods before and after Project intervention, due to the absence of baseline information.
2. The Project objective of improving maize-based cropping systems was indirectly reducing crop diversity in the catchment.
3. The areas under tobacco and vegetables may increase in the future, particularly in the lower flat area of the catchment.
4. The farmers' adoption/adaptation of Project technologies during the Project period was directly influenced by Project efforts (dissemination, training, subsidy and compensation). The long-term use of these technologies, without further intervention, is likely to change, once farmers are given complete freedom to determine their cropping strategy.
5. The use of contour cultivation by farmers has increased in the year after the cessation of the Project, as a result of Project intervention.
6. Farmers used polythene mulch for tobacco and vegetable crops, but they are not yet convinced to use it for the maize crop.
7. The use of intercropping was low and remained so after the Project.

8.2 The tree survey

8.2.1 Introduction

A tree planting scheme formed part of the catchment management plan. Three different tree species (sweet chestnut *Castanea mollissima* Bl., prickly ash *Zanthoxylum bungeanum* Maxim and hua shan pine *Pinus armandii* Franch.) were planted by the Project during 2000 and 2001. However, only limited monitoring was performed during the Project period. The present survey determined the status of the trees in 2002 and 2003.

8.2.2 Methodology

Observations were made by measuring the area of the sample plots and then counting the tree saplings. The observations were made from the terraced and unterraced sloping lands. In the case of unterraced areas, plots with a square or rectangular shape were demarcated to measure the area (Plate 8.1).

Plate 8.1 Tree survey, Wang Jia catchment, 2002. (Source: Author)

On terraced land, the width and length of the terrace was measured at several points in order to calculate the average dimensions of the uneven terraces. After measuring the area, the saplings were grouped into the following three categories before counting.

- *Dead trees:* identified either by finding the dead trees or the signs of planting present between two other existing trees,
- *Poor trees:* pale green leaf colour, thin and weak stem, poor branching, few leaves, poor canopy, poor vigour,
- *Good trees:* dark green colour, erect and strong stem, good branching, many leaves, good canopy, good vigour.

Sample plots for each of the species were randomly selected. The 2002 survey was repeated in 2003. Since the plots were selected randomly, the sample plots used in 2003 were different from those of 2002.

8.2.3 Results

8.2.3.1 Pine

The average planting density of the pine trees was 42.6 trees/100 m² in 2002 and 23.6 trees/100 m² in 2003 (Tables 8.8 and 8.9).

Table 8.8 Number of pine trees in randomly selected sample plots in Wang Jia catchment, 2002.

Plot No	**Number of trees/100 m²**				**Characteristics of sample plot**
	Good	**Poor**	**Dead**	**Total**	
1	14.0	6.0	5.0	**25.0**	Road, presence of gravel and small boulders; the area acts partially as a gully for runoff water.
2	18.8	11.3	18.8	**48.8**	Red soil, bare land, hard soil, exposed.
3	29.0	10.0	12.0	**51.0**	Grassland, small bushes, one tree. Small pine trees (seedlings) were covered by well-grown summer grasses.
4	23.0	8.0	14.0	**45.0**	Grassland, very small trees covered by well-grown grass.
5	23.0	11.0	9.0	**43.0**	Grassland, trees, bushes and small area, near a trekking trail.
Mean	**21.6**	**9.3**	**11.8**	**42.6**	

Table 8.9 Number of pine trees in randomly selected sample plots in Wang Jia catchment, 2003.

Plot No	**Number of trees/100 m²**				**Remarks**
	Good	**Poor**	**Dead**	**Total**	
1	14.4	13.6	NA	**28.0**	Top of the hill, along the side of a footpath, almost full cover of ground grasses, some bushes and 2 trees present, uncultivated land.
2	14.2	10.1	NA	**24.3**	Middle part of the hill, along the side of a footpath; almost full cover of ground grasses, some bushes and 2 trees present, uncultivated sloping land.
3	13.0	5.5	NA	**18.5**	Lower hill, uncultivated barren land just above the watchman's house, gentle slope, ~90% grass cover, some bushes (*Eupatorium adenophorium*) and 2 trees present. Other trees have also been planted, which are ~30-60 cm tall. This could be the reason for the low population of Project pines.
Mean	**13.9**	**9.7**	**NA**	**23.6**	

There was a large difference in the average number of trees between 2002 and 2003, due to:

- Recording dead trees was difficult and the records for 2002 were made by local farmers (who were involved in tree planting) and based on their experience and estimates. This information about dead trees was not recorded during the 2003 survey.
- Pine trees were planted in different types of area, including existing forest areas with different tree and bush densities and rocky barren sloping land with large proportions of rock and soil cover. In such situations, it had not been possible to plant trees maintaining the

recommended row and tree spacings. Planting in forest areas was undertaken to fill gaps and maintain the tree cover. Similarly, the presence of different sizes of rocks on slopes also made it difficulty to maintain the recommended density of the trees at the time of planting. Because of this, tree densities varied considerably. The tree densities observed during both the 2002 and 2003 surveys were lower than the recommended density (66 trees/100 m², Bi Fa Zhi, 2002, *pers. comm.*).

8.2.3.2 Prickly ash

The average tree density observed during the 2002 survey was 9.7 trees/100 m² (Table 8.10), while it was 7.3 trees/100 m² during the 2003 survey (Table 8.11). The average density observed during both years was close to the recommended density (8.3 trees/100 m², Bi Fa Zhi, 2002, *pers. comm.*).

Table 8.10 Number of prickly ash trees in randomly selected sample plots in Wang Jia catchment, 2002.

Plot No	**Number of trees/100 m^2**				**Remarks**
	Good	**Poor**	**Dead**	**Total**	
1	0.0	9.0	0.0	**9.0**	Abandoned terraces. Poor man's land, who thought that cultivation in this land was unprofitable, so gave up cultivation.
2	0.0	11.0	0.0	**11.0**	Abandoned terrace, tall grasses, well grown vegetation
3	0.0	9.0	2.0	**11.0**	Very poor sandy soil with fine stones (gravel), sloping land. The land was poorly covered and grasses are also poorly developed.
4	7.5	1.8	0.0	**9.3**	Cropland (maize), fairly good land and fair crop performance. Plot holder asked the Project staff to plant fewer seedlings on this land. He thought the trees would reduce crop production.
5	6.1	2.3	0.0	**8.4**	Cropland (maize), fair soil quality and crop performance, steep slope, small landslide damaging some crops, possibly some trees also.
Mean	**2.7**	**6.6**	**0.4**	**9.7**	

Table 8.11 Number of prickly ash trees in randomly selected sample plots in Wang Jia catchment, 2003.

Plot No	Number of trees/100 m²				Remarks
	Good	Poor	Dead	Total	
1	4.6	3.7	0.9	**9.1**	Top of the hill, barren terrace (looks previously cultivated), covered by grasses, ferns and small bushes. Thick vegetation (ground level)
2	5.0	0.0	0.5	**5.4**	Cultivated plot (maize), maize performance good, trees were also good.
3	5.1	2.8	0.0	**7.8**	Cultivated plot (maize), maize performance fair, trees were elongated rather than stocky (stout) growth.
4	4.6	3.3	0.0	**7.9**	Cultivated (small cabbage). Downslope + polythene, cabbage performance good, tree performance variable, terraced land.
5	4.5	1.5	0.0	**6.0**	Cultivated (maize), good performance of both crop and tree.
6	2.8	1.9	0.0	**4.7**	Cultivated (small cabbage) terrace land. Downslope + polythene mulch. Cabbage performance good but tree performance variable.
7	9.2	1.8	0.6	**11.6**	Cultivated terrace. Half of the plot was maize and the other half sunflower. Maize late but growth good. Performance of sunflower poor. Many prickly ash trees had grown well (~1.5 m tall with good vigour, canopy, leaf colour and growth).
8	3.9	0.9	0.0	**4.8**	Cultivated plot with tobacco. Steep terrace. Downslope + polythene mulch. Performance of tobacco fair but tree performance good.
9	5.3	4.1	0.0	**9.4**	Cultivated terrace with soybean (mono). No definite planting system. Crop performance fair, but tree performance poor.
10	5.8	0.4	0.0	**6.2**	Cultivated (maize), narrow terrace (some sunflower and French bean intercropped), downslope, good growth of both maize and tree.
Mean	**5.1**	**2.0**	**0.2**	**7.3**	

8.2.3.3 Sweet chestnut

The average tree density observed during 2002 was 8.9 trees/100 m² (Table 8.12) and in 2003 was 6.0 trees/100 m² (Table 8.13). The average observed density was higher than the recommended density of 4 trees/100 m² (Bi Fa Zhi, 2002, *pers. comm.*).

Table 8.12 Number of sweet chestnut trees in randomly selected sample plots in Wang Jia catchment, 2002

Plot No	Number of trees/100 m²				Remarks
	Good	Poor	Dead	Total	
1	0.0	8.5	0.9	**9.5**	Steep slope, uncultivated land, narrow and imperfect terrace, very variable terrace width, presence of tall grasses and bushes.
2	4.4	3.5	0.9	**8.7**	Cropland (maize), fair crop performance (even weeds are not vigorous). Just below the access road.
3	2.9	4.5	1.2	**8.7**	Cropland (maize), crop performance poor, however weeds had grown well. Top of the hill (adjacent to watchman's house) on the side of the highway.
4	4.1	3.3	0.8	**8.3**	Cropland (maize), just below the access road (near watchman's house), steep slope, poor crop performance, good weed growth.
5	5.1	2.5	1.7	**9.3**	Cropland (maize), sloping land (below watchman's house), good land and good crop performance, some radish trees and weeds.
Mean	**3.3**	**4.5**	**1.1**	**8.9**	

Table 8.13 Number of sweet chestnut trees in randomly selected sample plots in Wang Jia catchment, 2003.

Plot No	Number of trees/100 m^2				Remarks
	Good	Poor	Dead	Total	
1	2.3	0.8	0.0	**3.1**	Just below the Project road. Cultivated (maize) terrace, some pumpkin intercropped. Good maize crop.
2	3.2	6.4	0.0	**9.6**	Just below the Project road. Cultivated (maize) terrace. Some pumpkin intercropped. Variable maize performance.
3	1.9	2.5	0.6	**5.0**	Just below access road. Cultivated (small cabbage) terrace. Downslope + polythene mulch. Steep slope. Fair performance of vegetables.
4	2.3	3.6	0.0	**5.9**	Just below the Project road. Cultivated (small cabbage), downslope + polythene. Fair performance of vegetables.
5	3.3	4.9	1.6	**9.9**	Cultivated (maize) terrace, some French bean intercropped. Fair growth of maize.
6	2.3	2.1	0.2	**4.6**	Cultivated hilltop. Maize + French bean intercropping, but due to poor emergence of maize - some patches appear to be only French bean. Fair performance of both maize and French bean.
7	1.4	2.1	0.0	**3.5**	Cultivated (maize and French bean) terrace. Fair performance of both maize and French bean.
8	2.4	1.6	0.0	**4.0**	Cultivated (maize + French bean and some sunflower) terrace. Contour cultivation. Good maize, but fair French bean.
9	2.8	2.8	0.0	**5.7**	Cultivated (maize) terrace. Good maize. Few weeds.
10	2.6	5.7	0.0	**8.3**	Cultivated (maize) terrace. Steep slope, few weeds.
Mean	**2.4**	**3.3**	**0.3**	**6.0**	

8.2.4 Discussion

Relevant information about the tree planting programme was lacking. Without knowing the number of trees planted, it was not possible to calculate survival rate of any particular plot, so the information presented can only describe surviving trees. Moreover gaps had been filled, where seedlings did not survive. However, no observations had been made to record seedling mortality before gap filling.

Observations were made during summer (July-September) when the grasses were well grown, but the pine seedlings were very small, as the species used for planting was slow growing. So the small pine seedlings were hidden among well-grown grasses, which made it difficult to locate and record them. As a result, the number of trees recorded was greater than the initial estimates based on visual observations. The trees were also in inaccessible sloping areas, so it was very difficult to demarcate the plot and measure the area for observation.

In the case of prickly ash and sweet chestnut, the trees were planted at different densities for the following reasons:

- Terrace width: the width of terrace was not the exact multiple of the row or plant spacing of the tree,
- Farmers' wishes: some farmers wished to plant more trees on their plots, while others were concerned about the reduction in crop yield due to trees, so they decided to plant the trees thinly. Thus, farmers' decisions played a crucial role influencing tree densities in croplands.

Because of this variation in density, it is difficult to estimate production, productivity and productive life of the trees.

Some farmers who took over mature chestnut trees along with the land in 1982 (when land was distributed to farmers for the first time) did not know their early growth habit and production behaviour at an early stage. Other farmers had planted trees (i.e., after 1982) on their land but these were still young, so they had no information on the production potential or productive life of the mature trees.

Since maize was planted as extensively as possible, no space was left around trees. This had caused heavy competition between growing trees and well-grown (tall) maize. Thus, during summer, the trees suffered from competition for light and in winter growth was slow because of low temperature and moisture levels, all reasons for poor tree growth in general. As with pine, gap filling was done without records being kept, so there were no reliable data on survival rates.

8.2.5 Conclusions

1. The average pine tree density in the catchment was lower than the recommended density for the region.
2. The average prickly ash density in the catchment was close to the recommended density for the region.
3. The average sweet chestnut tree density in the catchment was higher than the recommended density for the region.

8.3 Diagnostic Erosion Survey (DES)

8.3.1 Introduction

Diagnostic Erosion Survey (DES) is a field-based estimation of the extent of erosion in a catchment. This is a more direct approach than traditional methods, designed to gain understanding of the dynamics of erosion (Turkelboom, 1999). DES was carried out to describe and partially quantify the erosion processes in the catchment at the end of the Project. The DES technique was used because it did not involve physical intervention or the imposition of artificial boundaries in the catchment, neither of which were possible at this stage. It was done to establish a limited baseline for future comparisons as the catchment management plan progressed.

8.3.2 Methodology

Five plots were identified, with differing altitudes, slope angles and land use systems representative of the range found in the catchment (Fig 8.3.1).

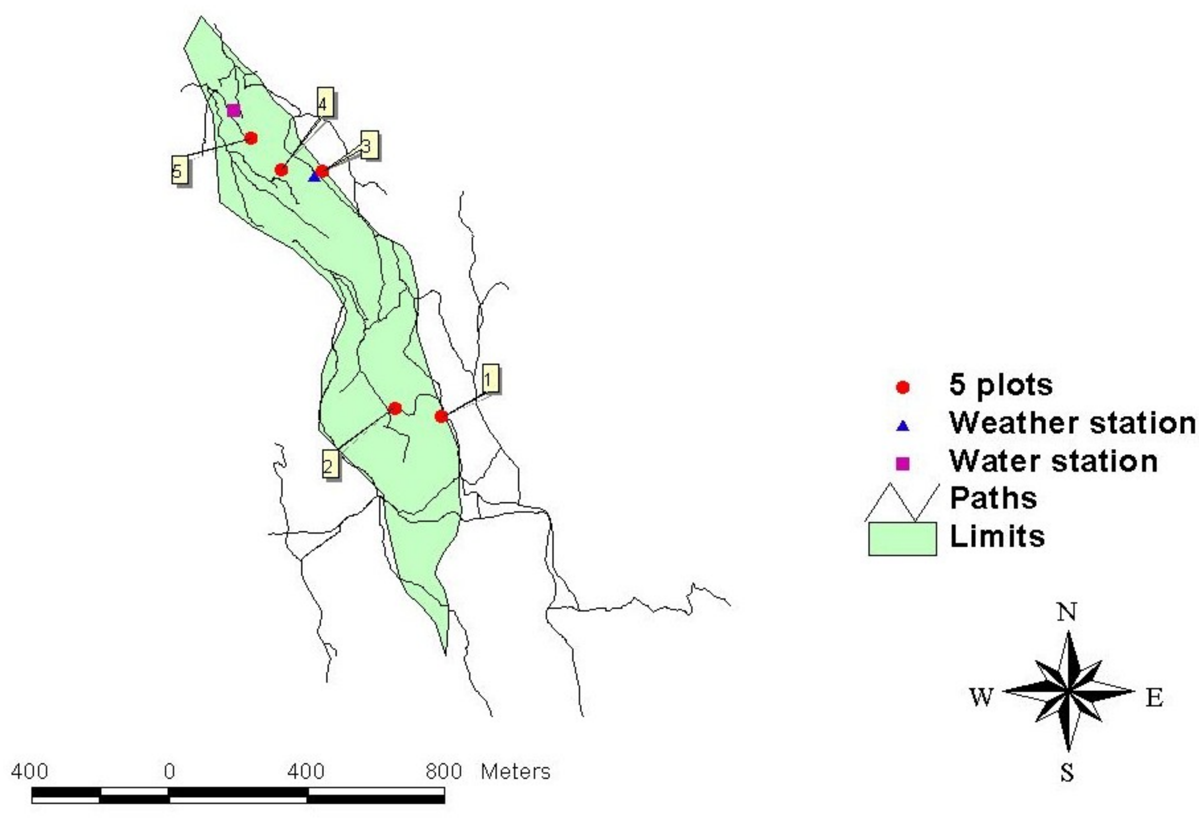

Figure 8.3.1 Location of the five DES study plots in the Wang Jia catchment, Yunnan Province, China.

The plots were selected from the bottom of the catchment (1985 m asl) to the top (2163 m asl) (Table 8.14). Slope of the plots varied from 9° to 40°. Three plots (Plots 2, 3 and 4) were selected from cultivated areas and two from uncultivated areas (Plots 1 and 5). Observations were made for rainfall, soil characteristics (soil texture, pH, N, P, K and soil organic matter), qualitative parameters (physiographic situation, rainfall characteristics, runoff and visual factors affecting soil water movement) and soil loss from different erosion features.

Table 8.14 Geographical details of the five observation plots, DES, Wang Jia catchment, Yunnan, China, Summer 2003.

Parameters	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**
Latitude	25º28.237'N	25º28.248'N	25º28.589'N	25º28.611'N	25º28.659'N
Longitude	102º53.150'E	102º53.060'E	102º52.934'E	102º52.862'E	102º52.809'E
Altitude	2163 m	2107 m	2027 m	1990 m	1985 m
Slope	17º	15º	9º	17.5º	40º
Aspect	South slope (facing N)	South slope (facing N)	East slope (facing W)	East slope (facing W)	East slope (facing W)
Plot size	600 m^2	285.4 m^2	166.1 m^2	147.9 m^2	225 m^2

8.3.2.1 Rainfall

Rainfall data for the period of May-September 2003 were recorded daily in the weather station in Kelang village established by the SHASEA Project.

8.3.2.2 Soil characteristics

Bulk Density: Measurements were taken in three places on each plot, in a diagonal across the plot. In Plot 1, six measurements were taken (three from the surface soil and three from the gully) and in Plot 5 four measurements were taken (two from the eroded and two from the uneroded area). Dry bulk density was calculated following the method outlined by Rowell (1994):

$$\text{Dry bulk density } (g/cm^3) = \text{Weight of oven dry soil (g)} / \text{Volume of cylinder } (cm^3) \qquad 8(1)$$

Soil Texture: Textural class was determined by the feel method. A ball of moist soil was squeezed between thumb and side of the forefinger, making a ribbon of the soil. Care was taken not to break the ribbon due to human movement, rather the ribbon was allowed to break up by its own weight. The length of the ribbon was considered to classify the soil, as proposed by Brady and Weil (1999).

Soil pH: A Whatman pH probe was used to measure soil pH. The probe was calibrated using buffer solutions of pH 4 and 7 before measuring the pH of the soil suspension. The pH value was recorded after 30 seconds, and readings were repeated.

Available Nitrogen (N): Analysis for available N was performed using a variation of the Conway method (Shi Ruihe, 1988) using the following equation:

$$\text{Available N} = ((V - V_o) \times N \times 14 / W) \times 1000 \qquad 8(2)$$

Where, V = Volume of H_2SO_4 used to titrate the sample (ml); V_o = Volume of H_2SO_4 used to titrate a blank sample (ml); N = Concentration of H_2SO_4; 14 = One equivalent of N; W = Dry weight of soil (g).

Available Phosphorus (P): The Olsen method was used to determine available P (Olsen and Sommers, 1982) and the following equation was used for the calculation:

$$\text{Available P (mg/kg)} = (C \times V \times D) / W \qquad 8(3)$$

Where, C = Concentration of solution, V = Volume of solution (ml), D = Dilution, W = Weight of oven-dried soil (g).

Available Potassium (K): The available K was calculated following the procedure presented by Allen (1989). The following equation was used for the calculation:

$$\text{Available K (mg/kg)} = (C \times V) / W \qquad 8(4)$$

Where, C = Concentration of solution, V = Volume of solution (ml), W = Weight of air-dried soil (g).

Soil organic matter (SOM) content: The analysis for SOM was performed by following the Walkley Black method (Walkley and Black, 1934). The following equation was used for the calculation:

$$\text{Organic C (mg/g of air-dried soil)} = (48\ (1 - X / Y))/\text{weight of air-dried soil (g)} \qquad 8(5)$$

Where, X = Amount of $FeSO_4$ used to titrate the sample (ml); Y = Amount of $FeSO_4$ used to titrate a blank sample (ml).

The result was expressed relative to the equivalent oven-dry soil weight. The value of organic carbon was converted to soil organic matter assuming that 58% of organic matter is organic carbon (Rowell, 1994).

8.3.2.3 Qualitative observations

Intensity and duration of rainfall, surface accumulation, rill formation and runoff characteristics of water and soil detachment and movement processes were studied during rain events. Observations about the erosion features were taken before and after rain events. The methodologies developed by Stocking and Murnaghan (2001) and Turkelboom (1999) was used in the Wang Jia catchment. The detailed methodologies are presented in Annex 8.2.

8.3.2.4 Observations on soil losses

In addition to descriptive assessments of the catchment, quantitative measurements of the erosion features were also performed in order to quantify soil and water losses through various erosion features. Soil losses from the following erosion features were studied:

Rills: A rill is defined as a shallow linear depression or channel in soil that carries water after recent rainfall (Stocking and Murnaghan, 2001). A rill is a product of the scouring action of runoff water. The soil loss from rills was calculated using the following equation (adapted from Stocking and Murnaghan, 2001).

$$\text{Soil loss t/ha} = ((0.5 \text{ x } W \text{ x } D \text{ x } L)/ \, Ca) \text{ x } BD \text{ x } 10000 \qquad 8(6)$$

Where, W = Width of the rill (m); D = Depth of the rill (m); L = Length of the rill (m); Ca = Catchment (contributing) area to rill (m^2); BD = Soil bulk density (t/m^3).

Gullies: A gully is a deep depression, channel or ravine in a landscape, looking like a recent and very active extension to natural drainage channels (Stocking and Murnaghan, 2001). The soil loss from gullies was calculated using the following equation (adapted from Stocking and Murnaghan, 2001).

$$\text{Soil loss t/ha} = ((0.5 \times (W_1 + W_2) \times D \times L)/ Ca) \times BD \times 10000 \qquad 8(7)$$

Where, W_1 = Width of gully at lip (m); W_2 = Width of gully at base (m); D = Depth of gully (m); L = Length of gully (m); Ca = Catchment (contributing) area to gully (m^2); BD = Soil bulk density (t/m^3).

Waterfall effects: This is soil loss from a depression or hole (scoop) created on the immediate downside of a plant or other obstruction. Such depressions or holes are created as a result of obstructions giving rise to a concentrated flow of water around the obstructing objects during times of heavy rain and overland flow on steep slopes (Stocking and Murnaghan, 2001). Soil loss from the waterfall effect was calculated using the following equation (adapted from Stocking and Murnaghan, 2001).

$$\text{Soil loss (t/ha)} = (((TSV/N) \times NoS)/A) \times BD \times 10000 \qquad 8(8)$$

Where, TSV = Total volume of soil lost from measured scoops (m^3); N = Number of scoops measured; NoS = Number of scoops in the field; A = Area of field (m^2); BD = Soil bulk density (t/m^3).

Scoop volume was calculated as;

$$\text{Scoop volume } (m^3) = \tfrac{1}{3}\, \Pi\, r^2 \times d \qquad 8(9)$$

Where, r = Scoop radius (diameter/2) (m); d = scoop depth (m).

Build-up against plant stems: This is the deposition of suspended particles in the runoff as a result of obstructions posed by plant stems leading to the moving water being halted. This results in a sediment accumulation against the barrier. It is an indicator for soil movement within the field rather than loss from the field (Stocking and Murnaghan, 2001). The soil accumulated against the plant stem (i.e. lost from the field) was calculated using the following equation (adapted from Stocking and Murnaghan, 2001).

$$\text{Soil loss (t/ha)} = ((TSV/Y)/ TCA) \times BD \times 10000 \qquad 8(10)$$

Where, TSV = Total volume of soil saved by plant stems (m^3); Y = Age of trees (years); TCA = Total catchment (contributing) area (m^2); BD = Soil bulk density (t/m^3).

TSV is sum of the volume saved by each plant stem measured and TCA is the sum of catchment (contributing) areas of each plant stems measured. The volume of soil saved by individual plant stems was calculated as:

$$\text{Volume saved } (m^3) = \tfrac{1}{2} \left(\tfrac{1}{3} \Pi \times r^2 \times d\right) \qquad 8(11)$$

Where, r = Distance from plant stem to the edge of the deposited materials (m); d = Depth of accumulation at the deepest point (m).

Sediment in drain: With cessation of flow of runoff water, transported sediments are deposited at the bottom of drainage channels, rills and gullies. The deposited sediment indicates the type and amount of material that has been eroded from the land above the drain (Stocking and Murnaghan, 2001). The soil deposited in the drain (i.e. lost from the field) was calculated using the equation (adapted from Stocking and Murnaghan, 2001).

$$\text{Soil loss t/ha} = ((W \times D \times L)/ Ca) \times BD \times 10000 \qquad 8(12)$$

Where, W = Width of drain (m); D = Depth of drain (m); L = Length of drain (m); Ca = Catchment (contributing) area to drain (m^2); BD = Soil bulk density (t/m^3).

8.3.3 Results

8.3.3.1 Rainfall at the study site

The total rainfall in Kelang village from May to September 2003 was 620.4 mm (Table 8.15). During this period, the village received rainfall on 55 days and the total daily rainfall was generally low for a monsoon period, as there were only three rain events during which rainfall exceeded 50 mm/day. The total rainfall was relatively low during August (65.7 mm) and September (113.6 mm), when the maximum rain in any particular day was <35 mm. Rainfall given for May is for part of the month only, from 20 May. Similarly the total rainfall for September is only for the first 26 days.

Table 8.15 Rainfall in Kelang village, Yunnan, China, during May-September 2003.

Months	**Rainfall mm**	**Range**	**No. of rainy days**	**Average daily rainfall mm***
May (20-31)	21.9	0-11.3	7	1.8 (3.1)
June	203.7	0-57.8	15	7.3 (13.6)
July	215.5	0-101.7	14	7.0 (15.4)
August	65.7	0-18.0	10	2.1 (6.6)
September (until 26)	113.6	0-33.0	9	4.4 (12.6)
Total	**620.4**	**0-101.7**	**55**	**4.8 (11.3)**

* - The number in the parenthesis is the average daily rainfall of the rainy days only.

8.3.3.2 Soil description of the observation plots.

The pH values of all five study plots were close to neutral, ranging between 6.45 and 7.06 (Table 8.16). Soil pH was similar for cultivated and uncultivated plots and there were no obvious effects of slope. According to the threshold values for red soils of Yunnan (Shi Ruihe, 1988), mineral N was low in all study plots (Table 8.17), while extractable P was high in all plots and extractable K ranged between medium and high. Soil organic matter (SOM) can effectively reduce runoff and sediment concentration in runoff water by increasing aggregate stability and encouraging infiltration (Le Bissonnais *et al.*, 1995). Zhang Taolin *et al.* (1999) suggested separate threshold values of SOM for uncultivated and upland areas of South East China (Table 8.18). SOM of the study plots ranged between 12.3 and 27.8 g/kg. Severe SOM deficiency was found in the area of landslides and in uncultivated-bare plots. The gully soil in Plot 1 had more SOM (slight deficiency) compared to the surface soil of the same uncultivated plot. Similarly, the uneroded vegetated area also had more SOM (moderate deficiency) compared to soils from adjoining eroded areas in Plot 5. SOM in cultivated uplands (Plots 2, 3 and 4) were in a range of slight deficiency to high. No difference was found between cultivated and uncultivated plots for available N, P, K, and SOM and the effect of slope was also not clear.

Table 8.16 Physical and chemical properties of soil (0-20 cm) of the five study-plots in Wang Jia catchment, DES 2003.

Plot No	**Soil texture**	**pH**	**Mineral Nitrogen (mg/kg)**	**Extractable Phosphorus (mg/kg)**	**Extractable Potassium (mg/kg)**	**Organic matter (g/kg)**	**Remarks**
1	Loam	6.89	29.2	12.9	76.1	12.3	Surface plot
1	Loam	6.80	35.5	31.9	160.1	27.8	Gully
2	Clay, loam	6.45	30.4	29.0	110.0	19.5	Cultivated plot
3	Clay, loam	7.01	45.3	30.7	113.7	24.1	Cultivated plot
4	Loam	7.06	28.6	21.3	87.0	15.8	Cultivated plot
5	Loam	6.76	22.8	10.2	95.5	20.5	Red soil in upper part
5	Loam	6.85	38.6	16.0	71.6	14.6	Grey and gravely soil from the bottom eroded part
	Average	**6.83**	**32.91**	**21.71**	**102.00**	**19.23**	

Table 8.17 Threshold value for the classification of available N, P and K for red soils in Yunnan.

Classification	Mineral Nitrogen (mg/kg)	Extractable Phosphorus (mg/kg)	Extractable Potassium (mg/kg)
Low	<50	<5	<60
Medium	50-100	5-10	60-100
High	>100	>10	>100

(Source: Li YongMei, 2004; Shi Ruihe, 1988).

Table 8.18 Threshold value for the classification of soil organic matter (SOM) for red soils in South East China.

Classification	Organic matter (g/kg)	
	Uncultivated	Upland
Severe deficiency	<15	<10
Moderate deficiency	15-25	10-15
Slight deficiency	25-35	15-20
Fertile	>35	>20

(Source: Zhang Taolin *et al.*, 1999).

The average pH value and extractable P concentration of the study plots was similar to the average catchment value (Li YongMei, 2004); however, the average extractable K and SOM concentrations were slightly low and the average mineral N concentration was very low in study plots compared to the catchment average.

8.3.3.3 Qualitative observations and soil loss measurements

8.3.3.3.1 Plot 1

Description of the plot

The plot was located on an exposed hilltop. This was an uncultivated plot, partially covered by grass (40%) and bushes. Some naturally occurring pine trees were present at the top above the plot. Part of the plot served as a footpath, which passed north to south (along the slope) through the west side of the plot. One large gully entered the plot from the top south east corner of the plot and passed down through the north east corner (Plate 8.2).

Descriptive observations

Before rainfall There were many clear signs of soil and water movement present in the plot including a lot of rilling. The courses of rills were irregular, due to obstructions (presence of plant, stones/rocks and hard soil due to strong cementing agents) in the natural flow path.

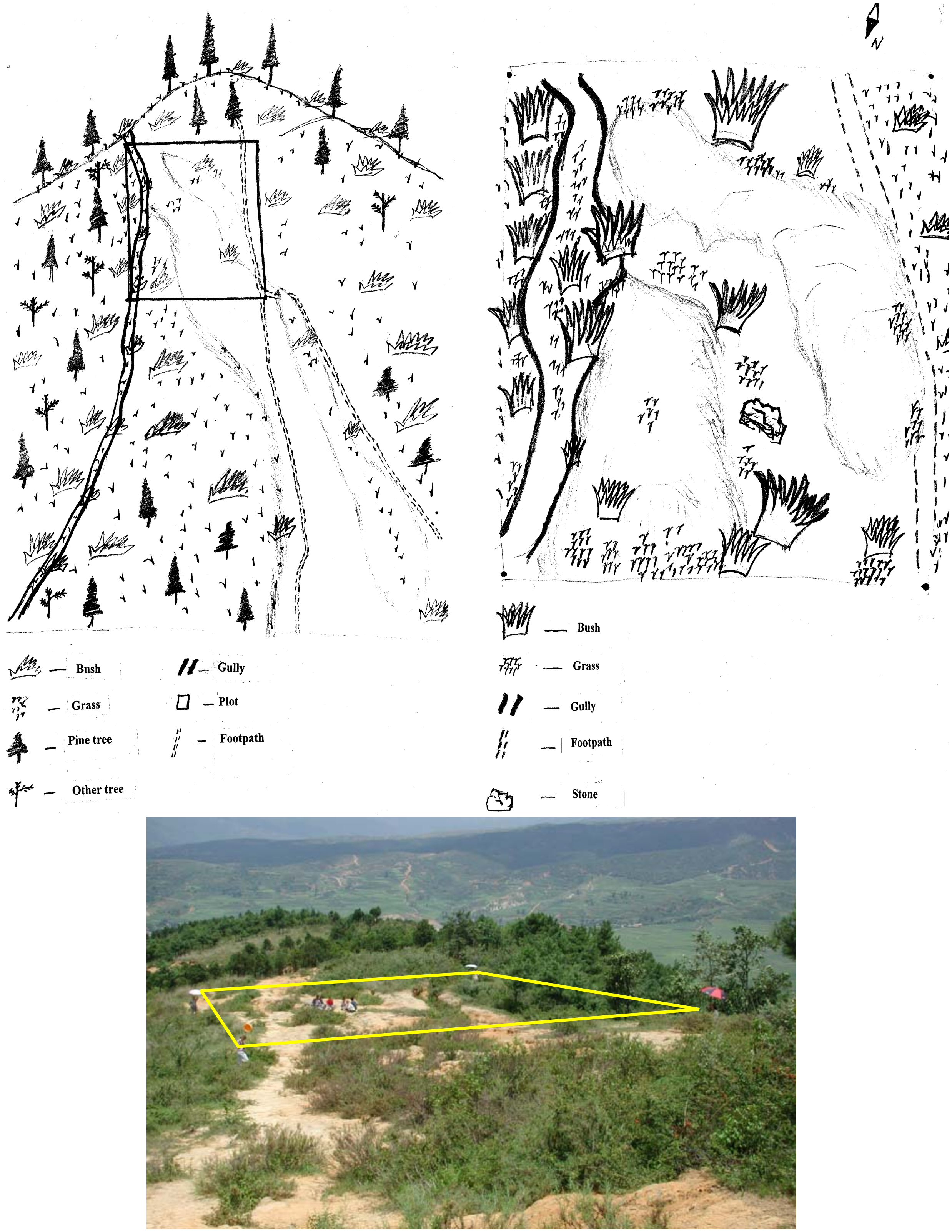

Plate 8.2 Broad view (top left) close-up view (top right) and photograph of Plot 1 used in Diagnostic Erosion Survey in Wang Jia catchment, 2003. (Source: Author)

Another reason for irregular courses could be the irregular distribution of cementing agents in the soil, making the soil of some areas harder than others. The distribution of soft and hard areas was irregular and patchy and flowing water was able to detach soil from the soft areas more readily than from hard patches. The width and depth of rills were also variable, leading to changes in the shape of the rills from narrow and deep to shallow and wide within short distances. There was strong evidence of soil deposition at the base of bushes or vegetation clumps within the observation area.

There were signs of active soil movement in the gully, as a large volume of fresh soil appeared to have slipped from the gully wall. Fresh loose soil was observed in the bottom of the gully while the section of the gully sidewall looked fresh and bright. This was distinctly different from the dull colour and presence of algae on other part of the wall.

During rainfall The effect of a period of rainfall on soil and water movement was observed and is presented in Table 8.19 as an example. The timings will vary depending upon duration and intensity of rain, slope angle, soil type, vegetation cover and many other parameters.

Table 8.19 Chronological order of rainfall events during a period of rainfall in Plot 1, Wang Jia catchment, Yunnan, China, 28 August 2003.

Event	Local time (hrs)	Time after rainfall started
Rainfall started	1330	-
Runoff started	1339	9 minutes
Surface accumulation started	1344	14 minutes
Runoff started	1347	17 minutes
Surface soil soaked (became muddy)	1353	23 minutes
Rain stopped	1353	23 minutes
Runoff stopped	1400	30 minutes
Water disappeared from the rill	1407	7 minutes

The surface soil appeared in two distinct categories due to the effect of rain, with hard and soft surfaces. The hard surface looked like the original surface, which was smooth, shiny and reflecting light. A thin water film was seen on the surface. This type of soil surface was less eroded by water, so the surface level of such hard patches was higher than the soft patches. The soil of the soft surface was rather loose and appeared like colluvial soil. The soil surface was rough, making soft patches look dark as they absorbed light, and infiltration was greater. The surface of soft patches was depressed compared with the hard patches. The distributions of hard and soft patches formed a mosaic pattern and their size and shape was variable.

An attempt was made to estimate the depth of infiltration in both superficially and soft patches of soil. Accurate estimation was difficult due to rainfall during the previous 24 hrs. It was more difficult on hard surfaces, because there was no clear demarcation between wet and dry soil. On soft surfaces, the soil in the upper layer that was soaked due to recent rain was softer and darker in colour than the soil that had been previously soaked. Water penetrated ~3 cm below the soil surface of the soft patches during the 30 minutes of rainfall.

After rainfall Soft surfaces were moister than hard surfaces. The sediment was deposited on soft bare soil but not on hard bare surfaces. Many sediments and pebbles (small stones) were found deposited on the vegetated (grassy) area.

Quantitative measurements

There was great variation in soil loss due to different erosion features. Soil loss from rills was 24.8 t/ha (Table 8.20), while it was 5410.7 t/ha from the gully. Soil loss due to the waterfall effect was 11.1 t/ha. Soil build up against the plant stems was 221.8 t/ha/yr. There was a large difference in the amount of sediment deposited in the rills (31.4 t/ha) and gully (301.5 t/ha).

Table 8.20 Comparison of soil losses from plot 1 through different soil and water loss processes in Wang Jia catchment, Yunnan, China, Summer 2003.

Erosion features	**Soil loss**
Soil loss from rills	24.8 t/ha
Soil loss from gully	5410.7 t/ha
Soil loss from water fall effect	11.1 t/ha
Build-up against plant stem	221.8 t/ha/yr
Sediment in drain. I. Rill	31.4 t/ha
Sediment in drain. II. Gully	301.5 t/ha

8.3.3.3.2 Plot 2

Description of the plot

This was a cultivated terrace (Plate 8.3), which ran in a north-south direction. The plot was surrounded by steep sloping hills in three directions (east, west and south). Runoff water could enter the plot from both the west and the south. Maize was grown and sunflower and pumpkin plants were intercropped under the maize. No specific planting system, neither contour cultivation nor downslope cultivation system, was followed.

Descriptive observations

Before rainfall There was no evidence of previous water and soil movement in the plot, as the soil had been recently disturbed during intercultural operations.

There were some clumps of *Eupatorium adenophorium* and *Artemisia vulgaris* on the eastern edge of the plot. Their canopies converged in places but their stems were sparsely distributed. Little soil build-up (deposition) against the clumps was observed. There were further clumps of these species on the southern border of the plot. This barrier was on the major slope and denser than the eastern barrier. Some signs of soil deposition against the bushes were observed. However, the plants were still young, so their effect on stopping soil and water movement could only be expected once the plants became strong and dense, producing tillers. In this plot, downslope soil movement occurred even in response to people walking on it. A steeper slope and recently tilled loose soil may be the reasons for this movement.

During rainfall Plant density in this plot was heterogeneous. Through fall of rain was observed where the plant population was small and in those places there were no soil clods, possibly broken down by raindrops. By contrast, soil clods were found in areas where plant density was high, possibly as a result of less through fall. Rain intercepted by the maize canopy dripped down from the tips of maize leaves and stem flow was not observed.

The water started to accumulate in depressions in the plot with a 15 minute period of increased rain intensity. The water became turbid as soon as it started to accumulate. This suggested the process of soil detachment and transportation had started along with overland accumulation and/or movement of water. Overland flow started in the plot after 17 minutes of rain, but this movement was just from one accumulated patch of depression storage to other accumulated patches, as spillovers. The water accumulated on the surface was not sufficient to develop continuous rills. Thus, the direction of water movement did not follow the slope of the catchment, due to insufficient water in the surface, rather water was moving towards more depressed areas nearby. The presence of maize plants in the water path also influenced the direction of water flow. It was observed that when the flowing water met maize plants, the water changed its path, sometimes in different directions. Such an irregular change in water path appeared to be due to the flow being on the surface, which perhaps would not have been the case if there had been rill formation to channel the flow.

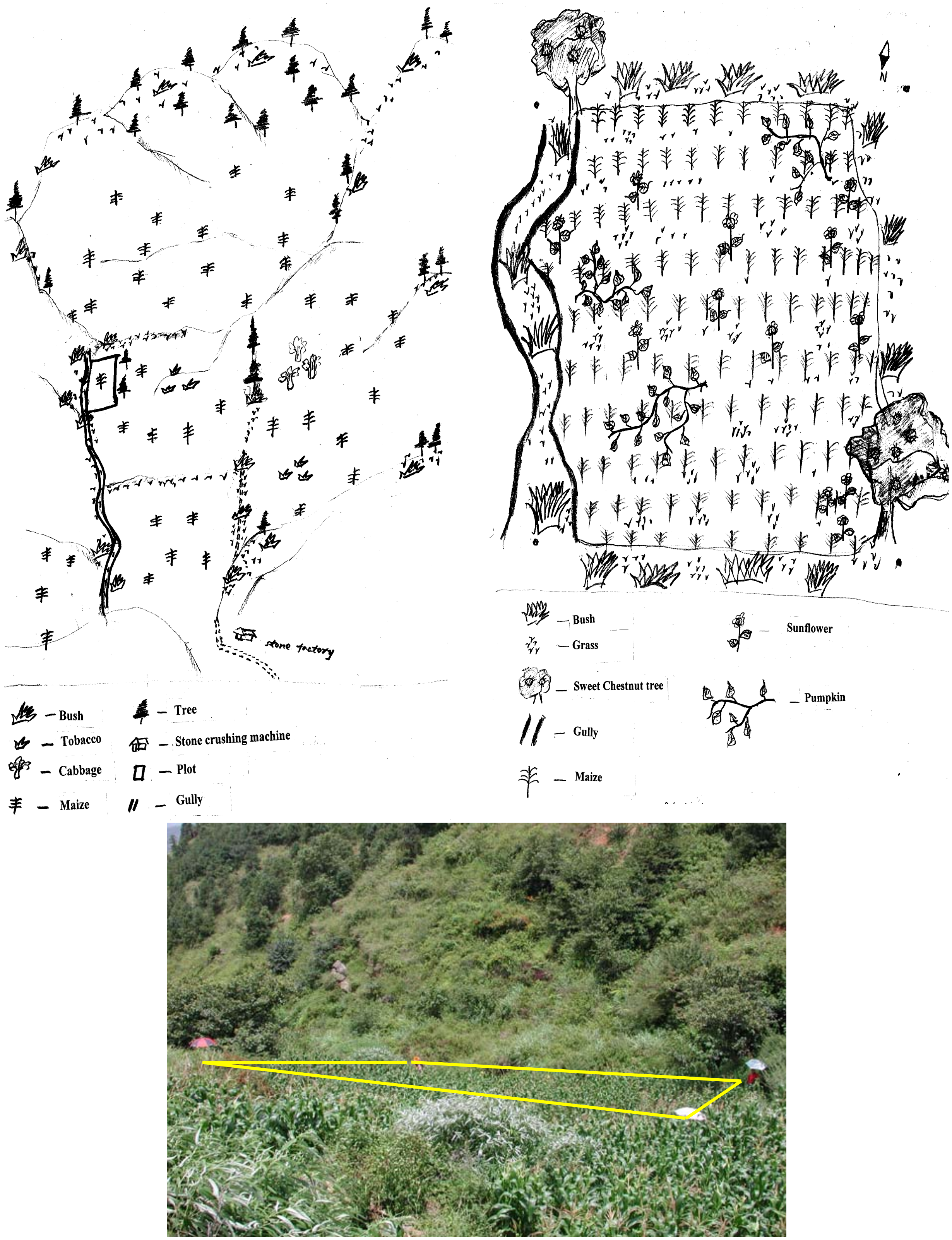

Plate 8.3 Broad view (top left) close-up view (top right) and photograph of Plot 2 used in Diagnostic Erosion Survey in Wang Jia catchment, 2003. (Source: Author)

There was a hedgerow on the northern border of the plot, which was situated across the major slope. Water flowed along the hedgerow (along the minor slope). The water could not penetrate the hedgerow on the major slope, so it changed its path to follow the minor slope.

After rainfall Evidence of surface flow of water was clear. However, the rills were open (shallow) and the margins of the rills were diffuse. Thus, a water path was detected, but it was difficult to demarcate the width and depth of rills. The water made its path between two plants, so the soil around the maize was much higher (9 cm high) than the soil between two maize plants. The water did not follow any straight route but zigzagged between the maize plants. This may have been due to periods of rain being short leading to no or insufficient water accumulation to develop rills. The water route was clear where maize density was low.

Quantitative measurements

Three different erosion features, viz. rills, waterfall effects and build up against plant stems, were observed in Plot 2. Soil loss from the rills was 188.0 t/ha (Table 8.21). It was 36.4 t/ha from the waterfall effect, while the amount of soil build up against plant stem was 107.6 t/ha.

Table 8.21 Comparison of soil losses from different observation plots through different soil and water loss processes in Wang Jia catchment, Yunnan, China, Summer 2003.

Erosion features	**Soil loss (t/ha)**
Soil loss from rills	188.0
Soil loss from waterfall effect	36.4
Build-up against plant stem	107.6

8.3.3.3.3 Plot 3

Description of the plot

Plot 3 was a cultivated terrace where maize was grown and was one of the experimental plots of the SHASEA Project. The terrace extended in an east-west direction. Contour cultivation was used for crop planting. Maize was grown in the adjoining terraces towards the east and west, while a narrow barren plot (extending east to west) lay on the northern side with a terrace with maize and French beans on the southern side (Plate 8.4).

Descriptive observations

Before rainfall No signs of previous water and soil movement were observed. As in Plot 2, evidence of soil and water movement had been destroyed during intercultural operations. There was a 45-cm wide grass-strip (*Seteria* spp) towards the bottom end of the terrace. The grass had

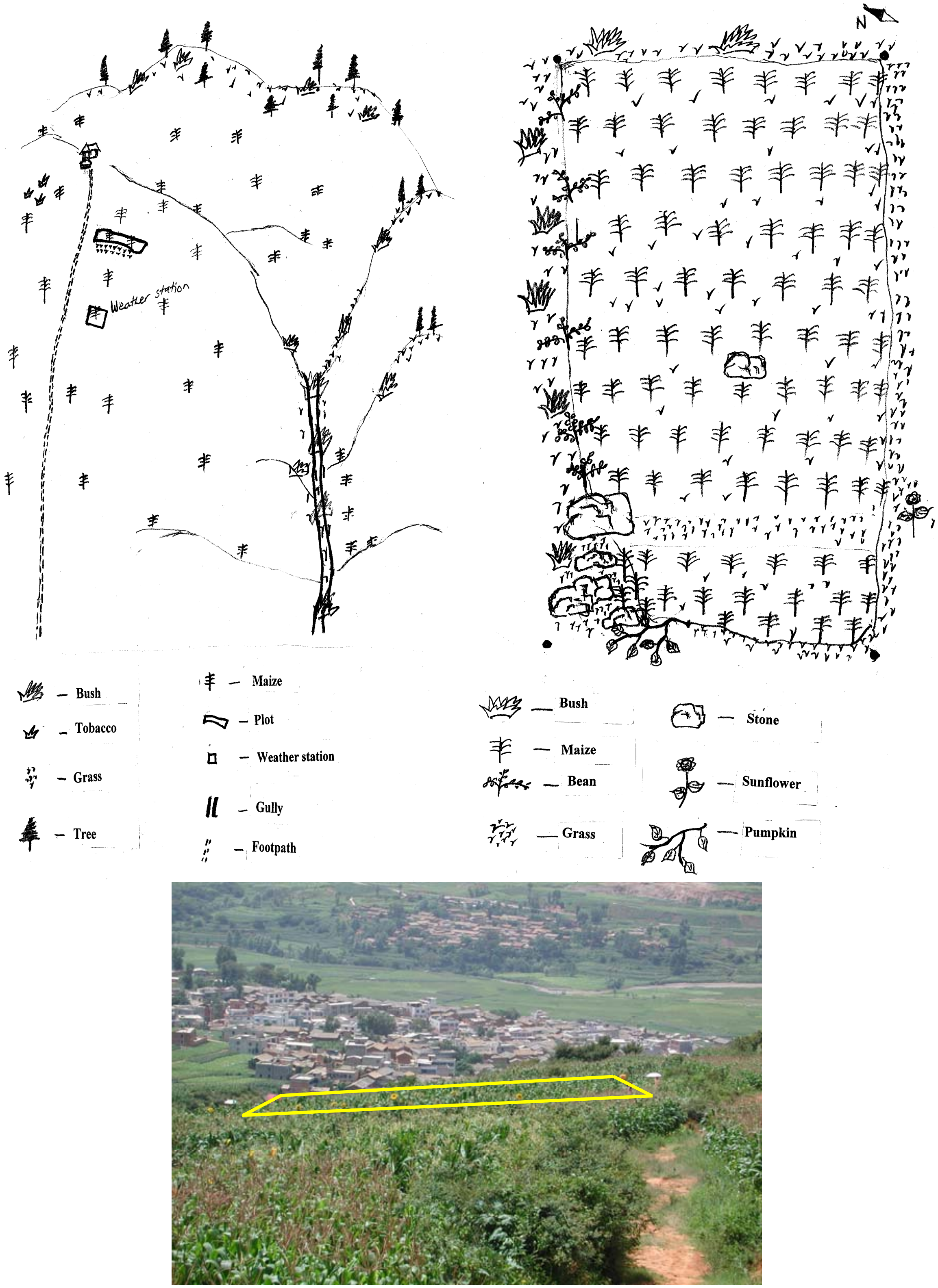

Plate 8.4 Broad view (top left) close-up view (top right) and photograph of Plot 3 used in Diagnostic Erosion Survey in Wang Jia catchment, 2003. (Source: Author)

poor vigour and low plant density with an average height of ~10 cm. It was clear that the grass strip was poorly managed and seemed ineffective in controlling soil and water movement. There was no evidence of deposition against the strip.

Loose soil was found on the terrace riser at the bottom end of the terrace. The soil was much looser and darker than both surface and sub-surface soils in the plot (Plate 8.5). It appeared that the deposited loose soil was the topsoil of the plot, transported by runoff water. The terrace riser was covered by grass, where soil was trapped.

Plate 8.5 Soil accumulated on the terrace riser was looser and darker than both surface and sub-surface soil in the plot. (Source: Author)

During rainfall Runoff started after ~20 minutes of rain with variable intensity. Runoff occurred only on the path because of the presence of contour ridges in the plot. The path extended from the top to the bottom of the plot along the slope and on the border of two plots. Generally, downward movement was stopped by the contour ridges, but where the ridges were not tall enough or broken, water ran down through that part of the ridge, but it was stopped again by the next ridge. There was little accumulated water in the furrow.

There was through fall of rain where the maize was not dense and canopy cover was poor. The water dripped down from the maize leaves, and stemflow was not observed.

Although contour planting was used, there was a little downward slope of the contour ridge towards the north, as it was an imperfect contour. Thus the accumulated water in the furrow flowed to the adjoining plot mainly towards the north. This water flow was across the slope and along the contour ridge. The impact of across slope movement of runoff water on soil erosion was certainly less damaging than along the slope, and this was a clear advantage of contour cultivation.

The effect of change in rainfall intensity was manifested immediately with a change in runoff water volume. Runoff water was turbid and transported organic matter and plant residues. The plot towards the north was a barren area, full of weeds. There was no runoff or water accumulation in that area. Depression storage was seen only in small patches.

After rainfall No rilling was observed and this was attributed to the use of contour cultivation. The furrows between the ridges served as man-made rills, as water flowed along the contour. Runoff velocity was very slow and impacts were much less destructive compared to water flowing down the slope.

8.3.3.3.4 Plot 4

Description of the plot

Plot 4 was a cultivated terrace where maize was grown. Soybean was intercropped under maize (Plate 8.6). There were two sweet chestnut trees in the plot. The terrace extended in a north-south direction surrounded by cultivated terraces in all directions. Peppers were grown on the eastern (upper) terrace, while maize was grown on the western (lower), northern and southern sides. Downslope cultivation systems were used on this plot.

Descriptive observations

Before rainfall Any evidence of previous soil and water movement had been destroyed during intercultural operations. The only evidence of soil water movement was found on the terrace riser at the bottom end of the terrace. Unlike Plot 3, the terrace riser was sliced down, so there was no grass on the riser. Thus water pathways were evident and in some places rills had formed due to the concentrated runoff. Sediment deposition on the terrace riser was not evident, due to the absence of grasses on the riser and in the lower terrace as a result of mixing during intercultural operations. The slope of the terrace riser in this plot was virtually 90°, while in Plot 3, the slope of the terrace riser was more inclined. As in Plot 2, there was evidence of downward movement of the soil caused by walking on the plot, due to the high slope angle (Table 8.14).

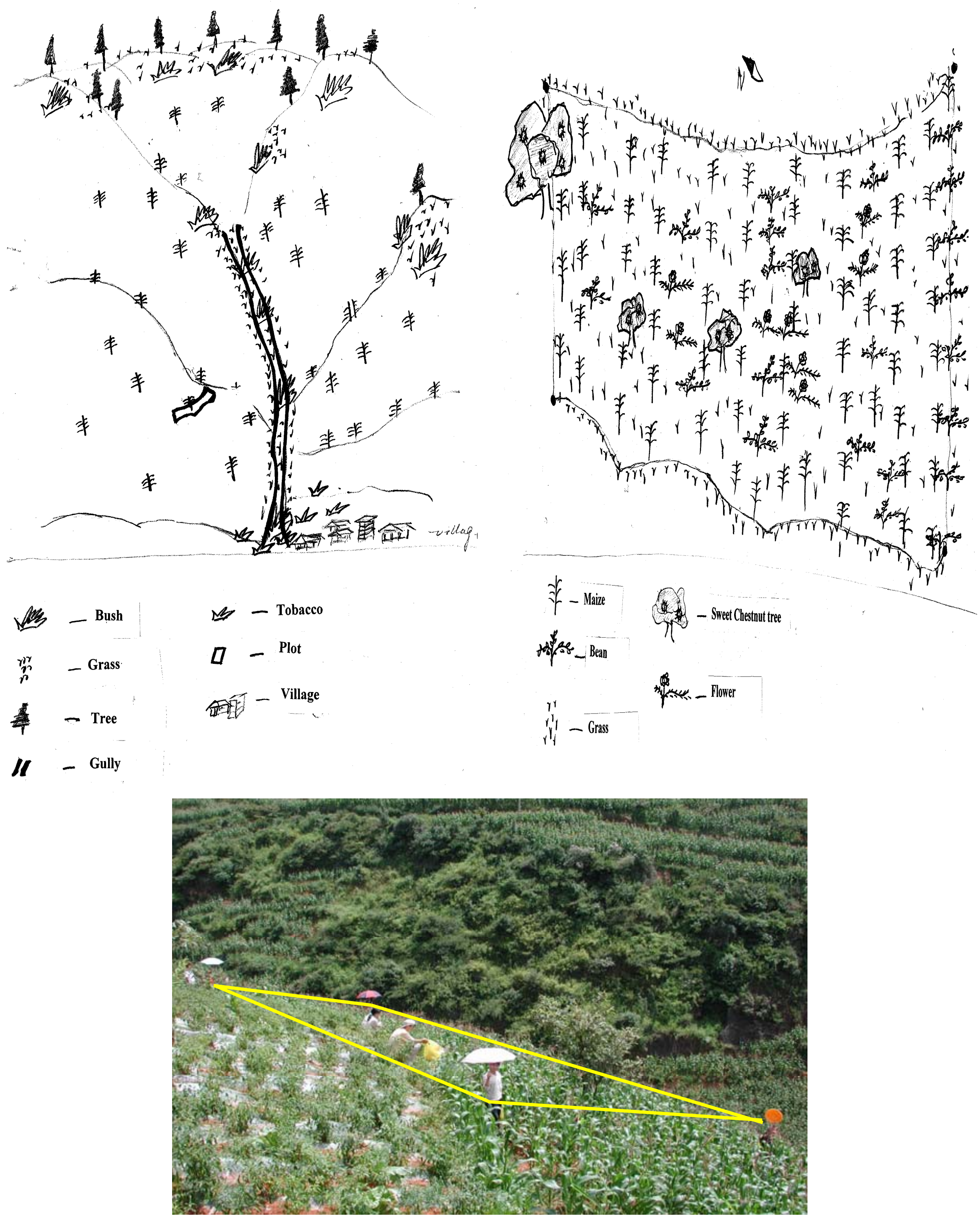

Plate 8.6 Broad view (top left) close-up view (top right) and photograph of Plot 4 used in Diagnostic Erosion Survey in Wang Jia catchment, 2003. (Source: Author)

After rainfall Observations were taken just after cessation of rainfall. The soil was very soft and footprints penetrated the soil reaching 15-20 cm below the surface. The furrows between the two ridges in the downslope cultivation system acted as the rill. The evidence of soil and water movement was clear, but the rills were very open, wide and shallow with diffused margins. It appeared that soil detachment and movement were taking place horizontally rather than vertically, which could have been due to the nature of soil. The soil in the Wang Jia is clayey, sticky and heavy. Evidence of overland flow was clearly observed. Some areas in the plot were more depressed, particularly where there was evidence of water movement. Small stones appeared along the rills, indicating the movement of topsoil from the water path.

8.3.3.3.5 Plot 5

Description of the plot

The observation plot was on uncultivated sloping land leading to a gully (Plate 8.7). Grasses and some bushes were growing on the uneroded narrow belt (~35% of the total area) at the top of the plot. The area below that narrow belt of vegetation (towards the bottom of the plot) was completely eroded, exposing sub-soils. There was a gully on the western side, an eroded sloping gully wall on the southern side and uncultivated barren areas (partly eroded-partly vegetated) towards the eastern and northern sides of the plot.

Descriptive observations

Before rainfall Soil movement was most active at this site and large sections of the plot were eroded. The slope was also very steep (Table 8.14). The top of the exposed area of the plot had signs of active landslip, from which patches of soil had rolled down slope. The landslip was advancing towards the top of the plot. In the upper portion of the eroded area, there was a concave shape caused by grasses holding the soil at the upper portion, but a little below that runoff was detaching and moving the soil. The soil there was vulnerable to wash-off due to the absence of grass. If runoff continued, then the under-cutting was likely to become deeper and the upper section of soil and grass collapse. The middle portion of the exposed area had less evidence of active soil movement, which could be due to the exposure of a hard sub-soil after the surface soil had been washed off. The bottom of the slope had some loose soil with variable sizes of gravel. Continuously running slurry was present at the boarder of the gully and plot. Active soil movement may have stopped due to cessation of rain.

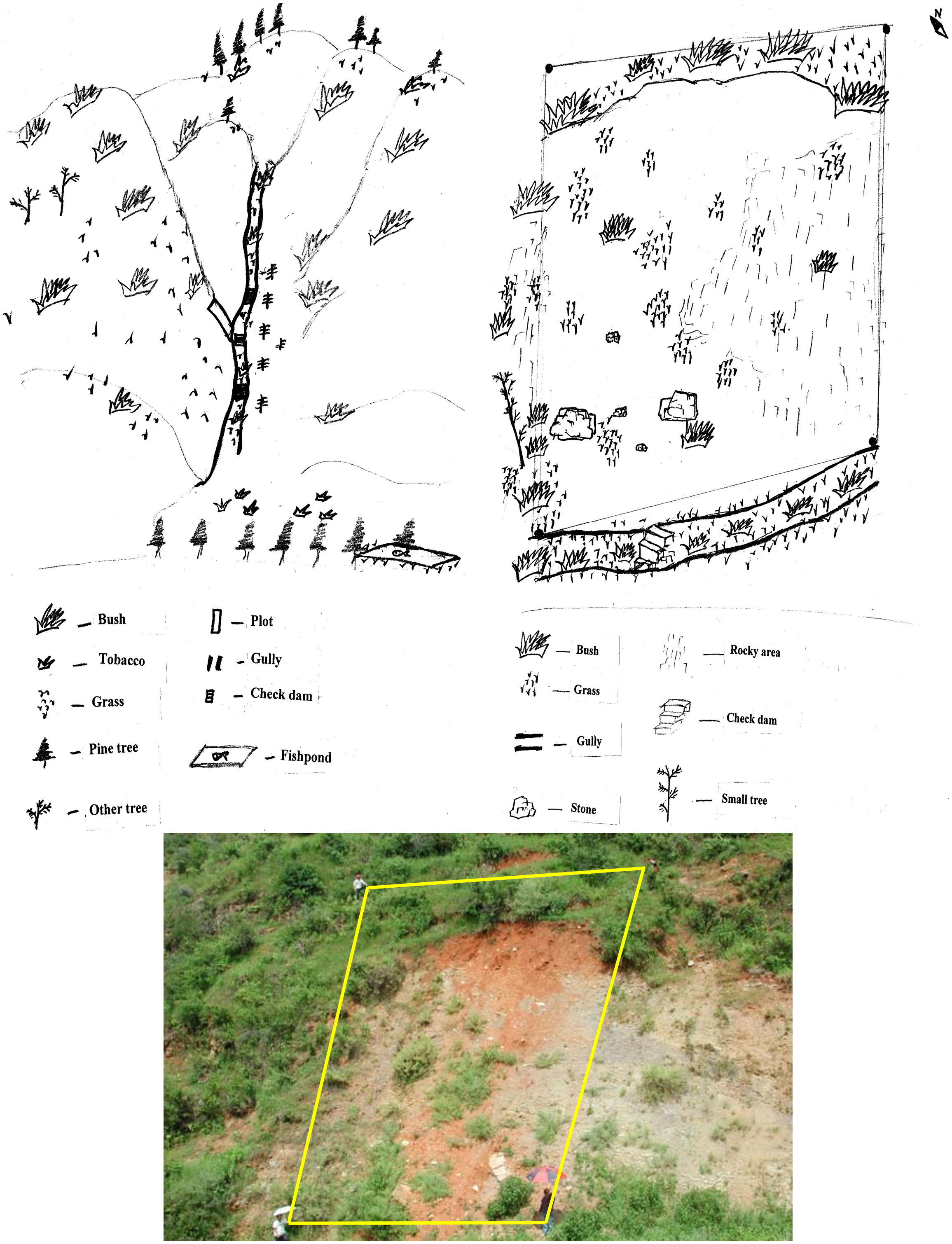

Plate 8.7 Broad view (top left) close-up view (top right) and photograph of Plot 5 used in Diagnostic Erosion Survey in Wang Jia catchment, 2003. (Source: Author)

After rainfall There were some rills in the plot, but no other evidence of soil water movement, other than the landslides. The large scale of the landslide might have masked or destroyed any evidence of other forms of soil and water movement. In addition, the slope of the plot was very steep and there was no vegetation cover to protect the soil. Under such conditions, any soil detachment would probably have led to the detached soil rolling down to the gorge, through the exposed loose surface of sub-soil.

Quantitative measurements

Apart from the landslide, a rill was the only erosion feature observed in this plot. Estimated soil loss from this rill was 22.2 t/ha.

8.3.4 Discussion

Imperfect contour ridges: Runoff was observed along contours where the contour ridges were not perfect, i.e., when the ridge did not follow the iso-line of the elevation. In such situations, a slope was created, which facilitated the flow of accumulated water along the ridge. In such cases, runoff was able to detach and transport soil. In addition, it was observed that farmers were interested in making the ridges long, so the ridges were constructed across the plot. Single continuous long ridges were observed even in plots with bidirectional slope. In such situations, the same ridge could run both along the contour line and also across the contour line in parts of the plot, serving the role of both a contour and a downslope ridge. Thus, despite the good intentions and actions of farmers to use contour ridges, they were still using downslope ridges at least in some parts of the plot. Pratap and Watson (1994) reported that incorrectly designed contour lines could aggravate soil erosion or be of little use.

Patterns of soil and water movement: Prominent rills were not observed, even in plots where downslope cultivation was practiced, but pathways of water flow were clearly observed. The pattern of sediment loss in heavy/clayey soil was different from that in loose, sandy soil. In heavy and sticky soil, runoff detaches surface soil only. Rills in such situations were open and shallow, with diffuse margins. The detachment and transportation of soil occurred horizontally rather than vertically. The width to depth ratio of water pathways was much greater than in light soil conditions.

Comparison of quantitative estimates of soil and water loss among the plots: Rill erosion was observed in three plots (Plots 1, 2 and 5). Soil loss from rills was much greater in cultivated land

(Plot 2) than uncultivated land (Plots 1 and 5, Tables 8.20 and 8.21). These figures do not account for soil lost through inter-rill erosion. The calculation was based on the cross-section area of the rill, so these figures only represent the amount of soil lost in the creation of these rills. Rills are the only visible manifestation of sheet erosion, where the total soil loss could be much greater than just soil removed from rills (Stocking and Murnaghan, 2001).

A gully was found only in Plot 1 (Table 8.20). As in the case of rills, the figure mentioned here was just the amount of soil displaced to create the gully. It does not take account of soil lost from adjacent soil surfaces. This means the soil loss could be much greater than this, so these values are only indicative and may be conservative.

Waterfalls were observed in Plots 1 and 2 only. The sediment loss due to the waterfall effect in the cultivated field (Plot 2) was much greater than in the uncultivated field (Plot 1, Tables 8.20 and 8.21), which could be because of the loose soil in the cultivated plot. Build-up against plant stems was detected in Plot 1 only and soil movement through this process was estimated to be 218.5 t/ha/yr (Table 8.20).

Sediment deposition was found in the bottom of the rills and gully in Plot 1, which was measured to estimate soil loss. The sediment deposition in the rills and gully was 31.0 t/ha and 338.5 t/ha, respectively (Table 8.20). The amount of sediment in the gully was >10 fold higher than in the rill.

Most of the erosion features were studied in uncultivated land, as they remained undetectable in cultivated land. Similarly, evidence of erosion features was lost due to mass movement of soil in the area of landslides.

Generally, erosion features were unrecognisable, particularly in cropland. The probable reasons were:

- The runoff path was not acute and clear and the detachment and transportation of soil was in a lateral direction rather than vertical. So evidence of water movement was clearer particularly at the bottom area of the plot. However, it was difficult to demarcate the width of such shallow bands with diffuse margins. Similarly, evidence of soil movement from the upper to lower terrace was detected, but it was not possible to estimate the amount of soil movement because the soil moving down from the upper terrace could not be distinguished from the soil of the lower terrace. Both foreign (transported) soil and plot soil looked the same.

- Low rainfall during both the entire rainy season and any particular rainy day was perhaps the reason for low soil and water movement during the Summer 2003. That could be one of the reasons for lack of distinct evidence of soil and water movement, particularly in croplands.

Rills in the cropland are continuously destroyed during cultivation and inter-cultural operations. Every season, new rills are created in cultivated land, possibly in different places. This could be one of the reasons why sediment deposition was not observed in the rills on cultivated land.

The calculation for 'sediment in rills and gullies' was performed following the methodology laid out by Stocking and Murnaghan (2001) for measuring sediments in drains, but in this case, the measurements were from rills and gullies. The drain is a man-made structure usually created across the slope, while rills or gullies are natural structures and usually flow along the slope. Obviously, there are differences in the amount of sediment deposition between drain and rill/gully systems, because of their differences in orientation. Before entering a drain, water flows down the slope. Once flowing water enters the drain, its direction of flow changes and velocity reduces. However, in the case of rills or gullies the direction of the flowing water remains the same and its velocity is likely to increase due to its concentrated flow through the channel. In such situations, the sediment is more likely to be deposited in the drain, while more is likely to be carried away by flowing water in the rills or gullies. Therefore the amount of sediment deposited in drains and the rills or gullies is different. Moreover, in rills and gullies, soil loss is usually from headwalls and sidewalls, and it accumulates at the end in the case of discontinuous rill or gully systems. The net loss of sediment from the field can therefore be very small, especially in the case of the gully shape moving upslope. Thus, information generated needs to be taken as indicative and regarded with caution.

8.3.5 Conclusions

1. Total rainfall in Kelang village during May to September 2003 was 620.4 mm, which occurred during 55 rainy days and total daily rainfall in most cases was <50 mm. The rainfall was relatively low during May, August and September.

2. Concentrations of mineral N were low in all study plots, while extractable P was high in all plots and extractable K of the study plot ranged between medium and high.

3. Severe soil organic matter (SOM) deficiency was found in the landslides area and in uncultivated bare plots. Soil in the gully had more SOM (slight deficiency) compared to the surface soil of the same uncultivated plot. Similarly, the uneroded vegetated areas had more SOM (moderate deficiency) compared to soils from the adjoining eroded area.

4. The pattern of sediment loss in heavy/clayey soil was different from that in loose, sandy soil. In heavy and sticky soil, runoff detaches the surface soil only. Rills in such situations were open and shallow, with diffuse margins. The detachment and transportation of soil was occurring horizontally rather than vertically. The ratio of the width to length of the water pathways was much higher than in light soil conditions.

5. On the basis of limited evidence, contour cultivation has potential to reduce soil and water erosion in sloping uplands.

6. Runoff was observed along the contour where the contour ridges were not perfect, i.e., when the ridge was not following the iso-line of the elevation.

7. Sediment loss due to runoff and the waterfall effect in cultivated fields was much higher than in uncultivated fields, which could be because of the loose soil in the cultivated plots.

8. The calculation of soil loss from rills and gullies was based on their cross-sectional area. The soil loss values are just the amount of soil displaced to create the rills and gullies, and it does not take account of soil lost from adjacent soil surfaces. This means the soil loss could be greater, so these values should be taken as indicative and conservative.

9. Most erosion features were studied in uncultivated land, as it remained undetectable in cultivated land. Similarly, the evidence of erosion features was lost due to mass movement of soil in the area of landslides.

8.4 Economic analysis

Detailed economic analysis was carried out as part of the Project under Work Package 3 (SHASEA, 2003; Liu HongMei, Thesis in prep.). A limited economic analysis was performed in this study based on the perceptions of a small number of farmers. The analysis was conducted to study the economics of two cropping systems modified by the Project.

8.4.1 Cultivated crop system

The economic analysis of cultivated crops was carried out to investigate the costs and benefits of different research interventions of the Project. A comparison was made between the options developed and extended by the Project and farmers' existing practices.

8.4.1.1 Methodology

The analysis was based on the valuation of the inputs and outputs associated with the different practices. A series of interviews with farmers and extension agents were made in 2002 to study the economic contribution of alternative technologies over the farmers' existing practices at household level. Respondents were first requested to list inputs required to adopt Project technologies and those required for the existing technologies. The input costs were worked out by multiplying the amount of input used by market price. The total input costs were calculated by considering only the cost of the inputs that varied between the two technologies. For example, the cost of manure was not considered if farmers had applied equal amounts to both mulched and unmulched plots. In this way, the production cost has been estimated at less than the actual cost. Output values were calculated by multiplying the amount of produce by farm gate price. Finally, the difference between the total inputs that varied and total output that varied was calculated to study the relative profitability of new technologies over existing practices. This difference can be considered as an indicator of the likely future adoption of Project technology.

8.4.1.2 Results

Cost-benefit was carried out on the following project technologies.

i. Net income from mulching in maize: Increase in net income from the straw+polythene mulching over no mulch was 945 Yuan/ha (Table 8.22). Similarly, increase in net income from polythene mulching over no mulch was 945 Yuan/ha. It interesting to note that the increase in net income from using two different types of mulching and by two farming households were the same. The increased net income from using straw mulch with maize could not be calculated, as no farmer used the straw mulch on its own.

Table 8.22 Economic analysis of maize cultivation under different mulching methods, Kelang Summer 2002.

Mulching method	Total income (Yuan/ha)	Costs that vary (Yuan/ha)	Net income (Yuan/ha)
Straw + polythene mulch	6000	1980	4020
No mulch	4500	1425	3075
Difference	**1500**	**555**	**945**
Polythene mulch	6000	1155	4845
No mulch	4500	600	3900
Difference	**1500**	**555**	**945**

ii. Net income from intercropping in maize: Intercropping was a common practice among farmers in Kelang village before the Project. A traditional method was to grow a few plants of sunflower, bean and/or pumpkin in maize plots. The density of the companion crop was generally very low. Frequently more than two crop species were mixed in one plot. Only a few farmers' practiced improved intercropping practices as recommended by agricultural technicians generally only in a small area, which meant the reliability of the data were limited. The Project worked on maize/soybean systems but very few farmers (only four in 2001 and 2002) used soybean for intercropping under maize (Li YongMei, 2004) and most of them did not harvest the soybean due to poor performance. So the cost-benefit of the maize/French bean intercropping system was studied. One analysis for maize and French bean showed an increase in the net income of 735 Yuan/ha (Table 8.23).

Table 8.23 Economic analysis of maize cultivation under an intercropping system, Kelang, Summer 2002.

Crop system	Total income (Yuan/ha)	Cost that vary (Yuan/ha)	Net income (Yuan/ha)
Maize + French bean	7125	1440	5685
Maize only	6000	1050	4950
Difference	**1125**	**390**	**735**

8.4.2 Tree planting systems

An economic analysis of tree planting systems was carried out to compare the net income from different tree species and crops over the growing period of trees. Comparison was made between the options developed and extended by the Project and farmers' existing practices.

8.4.2.1 Methodology

a. Estimates from discussion: A series of interviews with farmers and extension agents were made in 2002 to calculate the annual expenditure and income from crops and trees in different years. Farmers and extension agents were also interviewed in 2003 for additional information required to complete the analysis. The cost of inputs and income from the crop was calculated as described in Section 8.4.1. Respondents were requested to give lump sum amounts of annual costs for the trees. Then the annual production from the tree during the entire growing period was calculated. Output values were calculated by multiplying the amount of produce in each year by farm gate price.

b. Calculation of Net Present Value (NPV): The income from trees was converted to Net Present Value (NPV) to estimate the present value of the future income. The NPV was calculated for the income of crops as well in order to compare the incomes from crops and trees species. NPV is the discounted benefits of an investment, minus the cost of the investment (Sloman, 1991). The NPV allows consideration of the time value of money. Essentially, it helps find the present value of the future net cash flow of a project. If the NPV is greater than the cost, the project will be profitable or is worth undertaking (Pearce, 1981; Sloman, 1991; McAleese, 2001). The NPV is defined as (adapted from Pearce, 1981; SHASEA, 2003):

$$NPV = \sum_{t=0}^{n} \frac{NR}{(1+r)^t} = \frac{TR-TC}{(1+r)^1} + \frac{TR-TC}{(1+r)^2} + \frac{TR-TC}{(1+r)^3} + \cdots\cdots + \frac{TR-TC}{(1+r)^t} \qquad 8(19)$$

Where, NR = Net return; TR = Total return; TC = Total cost; r = Interest rate; t = the last year of production from tree

8.4.2.2 Results

Growth habit, production pattern and economics of growing sweet chestnut, prickly ash and pine trees were discussed with farmers from Kelang village and specialists from the Forestry Department of Kedu Township. Economic analysis of tree planting systems based on discussions with farmers was difficult due to differences in many parameters, such as growth stage, density and production potential of the trees, and farmers' knowledge and experience about trees. So the analysis was carried out using information provided by the Forestry Department of Kedu Township. Production behaviour of sweet chestnut and prickly ash trees under the situations in Yunnan were discussed, in order to understand patterns of income during the growth period of trees. Both tree species start producing fruit at around three years (Table 8.24). However, prickly ash starts to produce at its full potential from the 9th year, while sweet chestnut does so only from the 15th year after planting. Sweet chestnut has a longer productive life and age than prickly ash.

Table 8.24 Chronological order of the production behaviour of sweet chestnut, prickly ash and pine trees (from seedling) in Yunnan, China, personal discussion, Summer 2002 and 2003.

Time to attain	**Sweet chestnut**	**Prickly ash**
Initiation of production	3 Years	3 Years
25% production	8 Years	5 Years
50% production	11 Years	7 Years
75% production	13 Years	8 Years
Maximum potential Production	15 Years	9 Years
Maximum potential production maintained for	15-55 Years	9-19 Years
Production at reduced rate	55-100 Years	19-60 Years
Production reduced to 75%	65	25
Production reduced to 50%	70	30
Production reduced to 25%	80	40
Production reduced to minimum level	100	50
Average life of the tree	>100 Years	60 Years

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

There were large variations in the production potential of sweet chestnut and prickly ash trees (Table 8.25). The maximum potential yield (fresh weight) of a sweet chestnut tree (45 kg/tree) was nine times greater than that of prickly ash tree (5 kg/tree), however it was only 4 times greater per unit area (18225 kg/ha cf 4200 kg/ha) because of the higher plant density of prickly ash compared to sweet chestnut. The plant density recommended in Kedu Township was 405 trees/ha for sweet chestnut and 840 trees/ha for prickly ash (Table 8.26).

Table 8.25 Production pattern of sweet chestnut, prickly ash and pine trees (from seedling) in Yunnan, China, personal discussion, Summer 2002 and 2003.

	Sweet chestnut	**Prickly ash**	**Pine**
Age at first harvest	3 Years	3 Years	-
Yield at first harvest	3-4 seeds/tree	0.1 kg/tree	-
Age at maximum potential production stage	15 Years	9 Years	-
Yield at maximum potential production	45 kg/tree	5 kg/tree	-
Age at harvest	-	-	30 Years
Size at harvest (diameter of the log)	-	-	25 cm

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

Table 8.26 Recommended spacing and density of sweet chestnut, prickly ash and pine trees in Yunnan, China, personal discussion, Summer 2002 and 2003.

Species	**Spacing**	**Density (trees/ha)**
Sweet chestnut	5 x 5 m = 25m^2	~405 trees/ha
Prickly ash	3 x 4 m = 12m^2	~840 trees/ha
Hua shan pine	-	6600 trees/ha

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

The time required to produce a seedling of sweet chestnut plant was one year, while it was two years for prickly ash. These differences in the duration of nursery period would be expected to create a difference in the production costs of the seedlings. Despite the large variation in the time required to produce the seedlings, the cost of seedlings of sweet chestnut and prickly ash were similar. There was a large difference, however, in the price of produce (Table 8.27).

Table 8.27 Cost of seedling and price of produce of sweet chestnut, prickly ash and pine trees in Yunnan, China, personal discussion, Summer 2002 and 2003.

Species	**Cost of seedling**	**Price of produce**
Sweet chestnut	0.5 Yuan/seedling	5 Yuan/kg
Prickly ash	0.6 Yuan/seedling	9 Yuan/kg
Hua shan pine	0.05 Yuan/seedling	25 Yuan/tree (@ 300 Yuan/m^3 timber)

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

The production cost was much lower than the income from tree species at their maximum potential level of production (Table 8.28, Fig 8.4.1 and Fig 8.4.2). This means there was a very good benefit from planting trees, although the production from the trees during the early years was so low that the total annual income was less than that from the crops. In such a situation, farmers need to have the capacity to withstand the economic pressure posed by the reduced income due to tree planting. So the change in the annual income was studied to calculate the waiting period for the farmers to obtain as much annual income from the tree as from crops.

Table 8.28 Cost of production of sweet chestnut, prickly ash and pine trees in Yunnan, China, personal discussion, Summer 2002 and 2003.

Species	**Cost at the time of planting**	**Annual cost of production**
Sweet chestnut	1200 Yuan/ha	750 Yuan/ha/year
Prickly ash	450 Yuan/ha	450 Yuan/ha/year
Hua shan pine	150 Yuan/ha	150 Yuan/ha/year

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

Annual income from crops, sweet chestnut and prickly ash was also calculated to compare economic profitability, based on the productivity and farmgate price of the produce at the time of survey. The annual income from the crop was assumed to remain fairly similar over the years as the crops could produce at the potential level each year because of their annual growth habit. Therefore, the change in income over time remained relatively static during the entire period (Table 8.29, Fig. 8.4.1).

The income from trees remained zero for the first two years and then increased steadily until the tree attained its potential yield. For the initial few years tree income was less than the crops. Annual income of tree exceeded the annual income of crops from the 6th year onward (Fig. 8.4.2). Similarly the annual income of sweet chestnut exceeded the annual income of prickly ash from the 11th year onwards. Despite the higher yield of sweet chestnut, income was more from prickly ash during the first few years, which was mainly because of the high price of prickly ash (9 Yuan/kg) compared to sweet chestnut (5 Yuan/kg). Despite the lower yield potential, the prickly ash was better adapted to low temperature in the higher altitude compared to sweet chestnut. Considering the fact that most of the high slope angles lie at higher altitudes, the prickly ash is likely to be a more useful species at higher altitude.

The cumulative income from the trees, particularly the sweet chestnut, increased at an increasing rate, while the rate of increase was constant in the case of crops (Table 8.29, Fig. 8.4.3). The cumulative income from trees was lower than crops for the initial few years. The cumulative income from trees exceeded the cumulated income from crops from the 9th (prickly ash) and 10th (sweet chestnut) year onwards (Fig. 8.4.4). Similarly, the cumulated income from sweet chestnut exceeded the cumulated income from prickly ash from 12th year onward.

8.4.3 Discussion

The productivity of sweet chestnut (average 45 kg/tree) was very high compared to prickly ash (average 5 kg/tree, Table 8.25). Prickly ash being a small tree, the tree density is higher than sweet chestnut (405 cf 840 plants/ha). In addition, the selling price of prickly ash was also almost double that of sweet chestnut (9 Yuan/kg cf 5 Yuan/kg). However, the income of sweet chestnut still remained higher than prickly ash due to the higher production potential. This difference in the income influenced the farmers' decision about selection of tree species. Many farmers did not want to plant prickly ash even if the seedlings were given free; they preferred to buy seedlings of sweet chestnut (Bi Fa Zhi, 2002, *pers. comm.*).

Table 8.29 Comparison of incomes (Expressed as net present value) from crop (maize-wheat system), sweet chestnut (SC) and prickly ash (PA) cultivation systems in Yunnan Province, China.

Year	Net Present Value (Yuan/ha) of the income from					
	Crop/year	Crop cumulative	SC/year	SC cumulative	PA/year	PA cumulative
1	10737	10737	-1912	-1912	-883	-882.53
2	10473	21211	-717	-2629	-430	-1312.94
3	10162	31373	1183	-1446	3090	1777.49
4	9912	41285	4820	3374	5068	6845.04
5	9542	50828	8170	11544	7843	14688.15
6	9283	60111	11382	22926	11796	26484.48
7	9031	69143	14413	37339	15217	41701.87
8	8786	77929	17678	55017	22387	64088.94
9	8548	86477	23126	78143	29156	93245.27
10	8316	94793	28265	106408	28365	121610.21
11	8090	102883	33109	139517	27595	149205.26
12	7871	110753	40215	179732	26846	176051.30
13	7657	118410	47266	226998	26117	202168.66
14	7449	125859	53215	280213	25408	227577.13
15	7247	133106	59812	340024	24719	252295.94
16	7050	140156	58188	398212	24048	276343.82
17	6859	147015	56609	454821	23395	299738.97
18	6673	153688	55072	509893	22760	322499.12
19	6492	160179	53577	563471	22142	344641.49
20	6315	166495	52123	615594	20669	365310.82
21	6144	172639	50708	666302	19260	384570.77
22	5977	178616	49332	715634	17912	402482.60
23	5815	184431	47993	763627	16623	419105.33
24	5657	190088	46690	810318	15195	434300.43
25	5504	195591	45423	855741	14023	448323.16
26	5354	200946	44190	899931	12718	461041.13
27	5209	206154	42991	942922	11474	472514.84
28	5067	211222	41824	984746	10288	482802.47
29	4930	216152	40689	1025434	9157	491959.95
30	4796	220948	39584	1065019	8081	500041.05
31	4666	225614	38510	1103528	7540	507580.66
32	4539	230153	37465	1140993	6865	514445.54
33	4416	234569	36448	1177441	6221	520666.74
34	4296	238865	35458	1212899	5756	526422.48
35	4180	243045	34496	1247395	5311	531733.42
36	4066	247111	33560	1280955	4746	536479.12
37	3956	251067	32649	1313603	4344	540822.89
38	3848	254915	31763	1345366	3827	544650.21
39	3744	258659	30900	1376266	3465	548115.16
40	3642	262302	30062	1406328	2994	551108.86
41	3543	265845	29246	1435574	2741	553850.04
42	3447	269292	28452	1464026	2476	556326.43
43	3354	272646	27680	1491705	2224	558550.36
44	3263	275909	26928	1518634	2006	560556.24
45	3174	279083	26197	1544831	1798	562354.28
46	3088	282171	25486	1570318	1579	563932.96
47	3004	285175	24795	1595112	1370	565302.85
48	2923	288098	24122	1619234	1191	566494.32
49	2843	290941	23467	1642701	1022	567516.04

Year	Net Present Value (Yuan/ha) of the income from					
	Crop/year	Crop cumulative	SC/year	SC cumulative	PA/year	PA cumulative
50	2766	293707	22830	1665531	841	568357.24
51	2691	296398	22210	1687741		
52	2618	299016	21607	1709348		
53	2547	301563	21021	1730369		
54	2478	304041	20450	1750820		
55	2411	306451	19895	1770715		
56	2345	308797	18922	1789637		
57	2281	311078	17881	1807517		
58	2220	313298	16882	1824400		
59	2159	315457	16025	1840424		
60	2101	317558	15104	1855528		
61	2044	319601	14316	1869844		
62	1988	321589	13468	1883313		
63	1934	323524	12745	1896057		
64	1882	325405	12051	1908108		
65	1831	327236	11301	1919409		
66	1781	329017	10253	1929661		
67	1733	330750	9254	1938915		
68	1686	332435	8301	1947216		
69	1640	334075	7469	1954685		
70	1595	335670	6529	1961214		
71	1552	337222	6065	1967279		
72	1510	338732	5551	1972830		
73	1469	340201	5129	1977958		
74	1429	341630	4659	1982618		
75	1390	343021	4276	1986893		
76	1353	344373	3847	1990740		
77	1316	345689	3499	1994239		
78	1280	346969	3108	1997347		
79	1245	348214	2736	2000083		
80	1212	349426	2438	2002521		
81	1179	350605	2262	2004783		
82	1147	351751	2095	2006878		
83	1116	352867	1935	2008813		
84	1085	353952	1782	2010596		
85	1056	355008	1636	2012232		
86	1027	356035	1497	2013729		
87	999	357034	1364	2015092		
88	972	358007	1237	2016329		
89	946	358952	1072	2017401		
90	920	359873	958	2018359		
91	895	360768	849	2019208		
92	871	361638	746	2019954		
93	847	362486	647	2020601		
94	824	363310	553	2021154		
95	802	364112	464	2021618		
96	780	364892	379	2021998		
97	759	365651	299	2022296		
98	738	366389	222	2022519		
99	718	367107	150	2022669		
100	699	367806	81	2022750		

(Source: Bi Fa Zhi, 2002, *pers. comm.*)

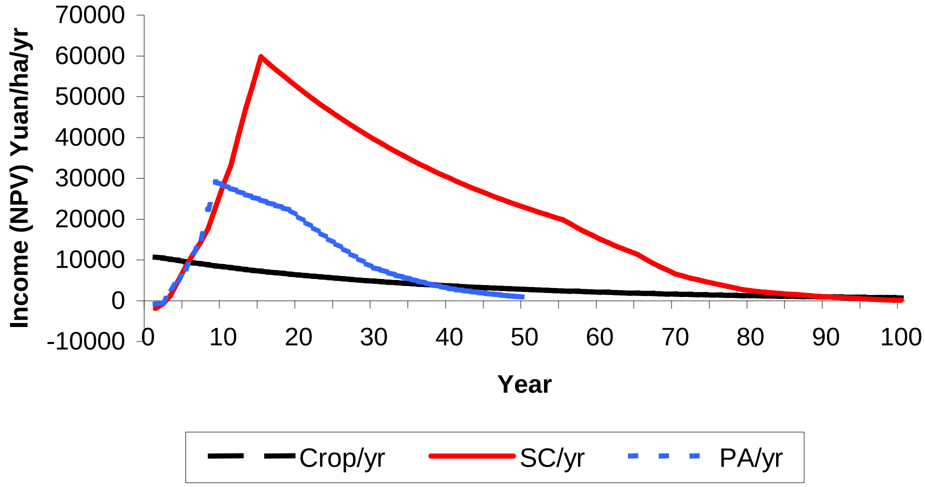

Figure 8.4.1 Long-term comparative annual income (in terms of Net Present Value) Yuan/ha/year from annual crops, sweet chestnut (SC) and prickly ash (PA), Yunnan Province, China, 2002-03.

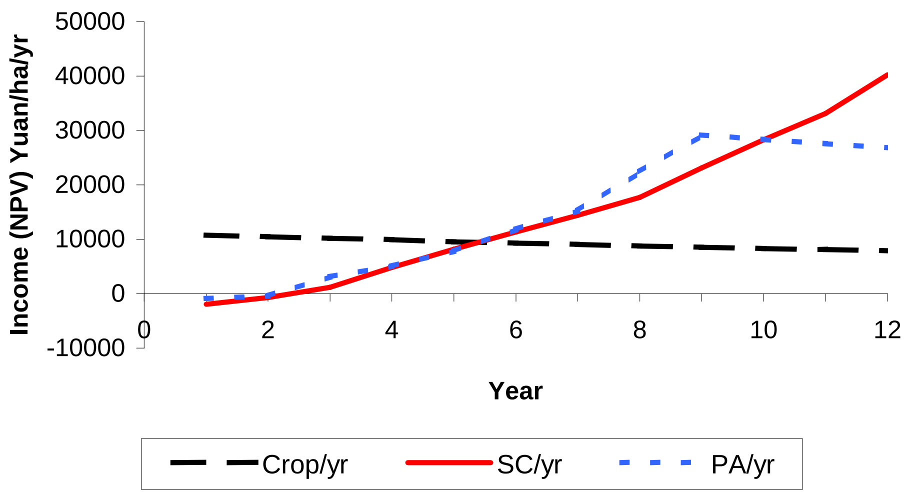

Figure 8.4.2 Short-term comparative annual income (in terms of Net Present Value) Yuan/ha/year from annual crops, sweet chestnut (SC) and prickly ash (PA), Yunnan Province, China, 2002-03.

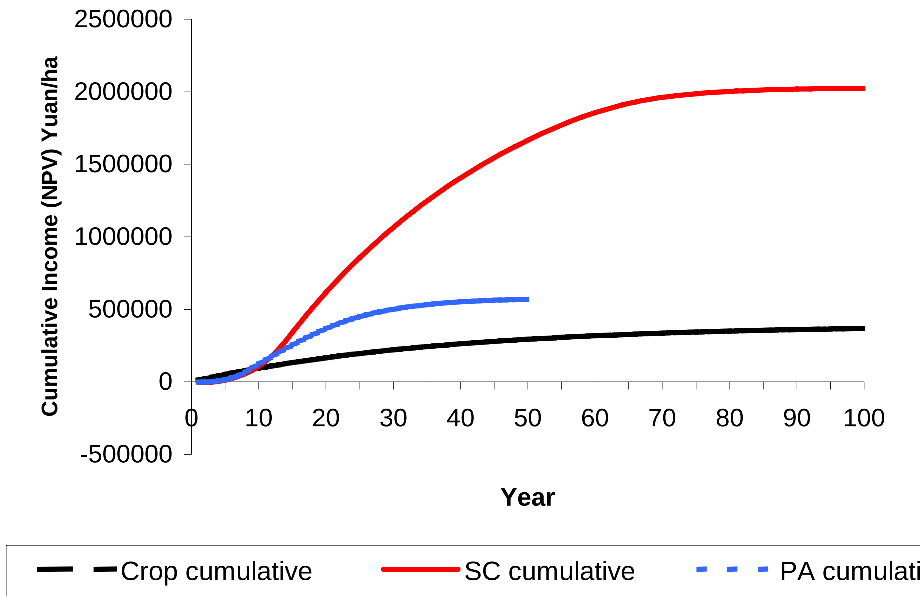

Figure 8.4.3 Long term comparative Cumulative income (in terms of Net Present Value) Yuan/ha from annual crops, sweet chestnut (SC) and prickly ash (PA), Yunnan Province, China, 2002-03.

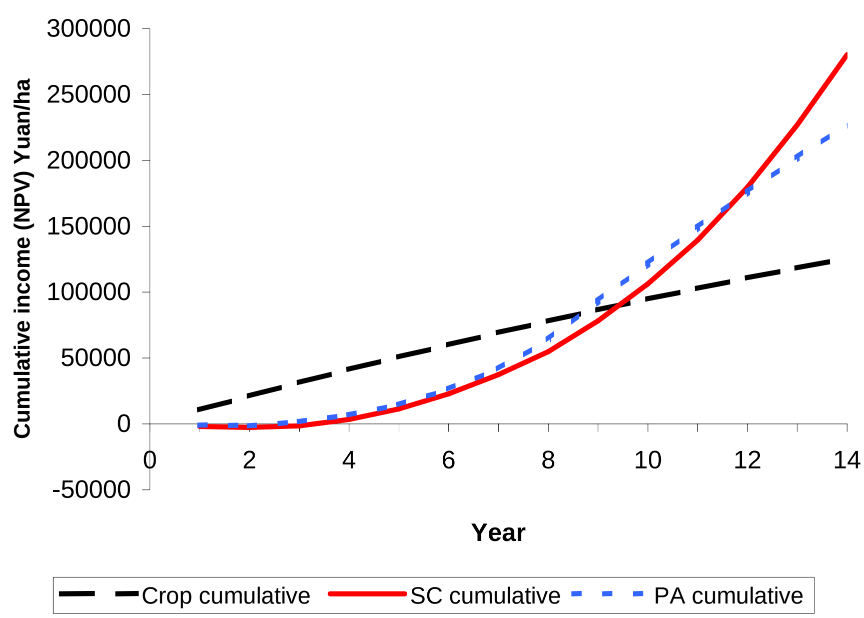

Figure 8.4.4 Short-term comparative Cumulative income (in terms of Net Present Value) Yuan/ha from annual crops, sweet chestnut (SC) and prickly ash (PA), Yunnan Province, China, 2002-03.

The Chinese Government is trying to stop cultivation of crops on land with slope angle $>25^0$ (Tang Ya *et al.*, 2003; Zhu Xioke, 2003, *pers. comm.;* Shi *et al.*, 2004). This policy is being adopted to decrease soil water losses from sloping areas. This policy has greater implications for Yunnan Province because ~70% of its 6.63 million hectares of cultivated land is located on sloping areas (Huang BiZhi, 2001). Some other Provinces are trying to address this policy by reducing the slope angle of arable land (through terracing), but Yunnan Province has decided to increase vegetation cover in steep slope areas to reduce soil and water losses by planting perennial trees (Zhu Xioke, 2003, *pers. comm.*). It follows that large scale operations will be required to translate the policy into practice. In such a situation, any technical and socio-economic findings can have a significant impact.

In the long run, the income from trees, particularly sweet chestnut, was much higher than crops. This indicates that the tree planting technology is a very profitable and environmentally-friendly option. However, the initial six years would be difficult for the poorer sections of society, due to lower income from trees compared to existing income from crops. For successful extension of tree planting, the programme must be accompanied with either subsidy provision until the tree income is at least as much as crops, or suitable quick income-generating agro-forestry interventions (for example, vegetables or flower production). Without this support, adoption of tree planting by poor farmers is likely to be limited.

8.4.4 Conclusions

1. Polythene or polythene + straw mulching both were economically profitable options for maize. The income from both of these mulching options was more than no mulching by 975 Yuan/ha. Similarly, the income from maize/French bean intercropping was more than monocropped maize by 735 Yuan/ha.

2. Both sweet chestnut and prickly ash tree species start producing fruit at around three years. However, prickly ash starts to produce at its full potential from the 9th year while sweet chestnut does so only from the 15th year after planting. Sweet chestnut has a longer productive life than prickly ash.

3. The potential yield (fresh weight) of sweet chestnut was 18225 kg/ha, which was >4 times greater than that of prickly ash (4200 kg/ha).

4. The potential benefits from sweet chestnut and prickly ash trees were much greater than for crops. However, the income from trees was less than crops for the initial few years. Annual income of trees exceeded the annual income of crops from the 6th year onward. The annual income of sweet chestnut exceeded the annual income of prickly ash from the 11th year onwards. The cumulative income from trees exceeded the cumulative income from crops from the 9th (prickly ash) and 10th (sweet chestnut) year onwards. The cumulated income from sweet chestnut exceeded the cumulated income from prickly ash from the 12th year onward.

5. The initial six years would be difficult for the poorer sections of society, so the tree-planting programme must be accompanied with either subsidy provision or alternative income-generating options for the early years.

Chapter 9: Discussion, synthesis and conclusions

The results described in the 5-8 are discussed, an attempt is made to synthesise the outcomes from the different approaches employed and final conclusions and recommendations are made.

9.1 Background to the SHASEA Project

In many parts of the developing world over the past five decades, increasing agricultural production has been the highest priority of agricultural development projects. Until the 1970s, the emphasis was on achieving higher agricultural productivity, with little regard for sustainability (Brady, 1990; Pretty, 1995). The concept of sustainability only emerged during the early 1980s (Jackson, 1980; Rodale, 1983; Harwood, 1990; Shepherd, 1998). Consequently, development activities in the early years focussed on increasing production through intensification of cropping systems without due attention to the resultant effects on natural resources. As a result, large areas of the world are now facing problems of soil degradation (Hurni, 2000), water erosion, groundwater pollution and natural resources depletion and the sustainability of current agricultural systems is in question (Rigby *et al.*, 2001; Rasul and Thapa, 2004; Röling, 2005). This situation is more apparent in poor and developing countries, which depend more on agriculture and natural resources for their income. For example, the sloping highlands of South East Asia have witnessed considerable pressure due to water erosion, land degradation and low farm productivity (Treitz, 1991; Rerkasem, 1995; Fullen *et al.*, 2002; Barton *et al.*, 2004; Lu, 2004).

In Yunnan Province, most of the cultivable land is not only suffering from soil erosion *per se*, but also contributing to sediment loading of the Yangtze River and hence downstream flooding (Huang BiZhi, 2001). Similarly, crop yields on sloping land in South China have decreased by 30-60% because of soil erosion (Gao Zhu and Zhou Lie, 1988). It has been predicted that most of the topsoil will disappear within the next 100 years if current erosion rates continue (Shi Deming, 1987). Thus, more effective soil and water conservation, while maintaining or increasing productivity, have become essential goals if agriculture is to be sustained on sloping land in these highland areas.

In this context, the SHASEA (Sustainable Highland Agriculture in South-East Asia) Project was planned to investigate more holistic approaches for the development and evaluation of agronomic and soil conservation measures, designed to improve the productivity and sustainability of cropping systems at a field scale. The SHASEA Project was implemented in Wang Jia catchment in Kelang village in Yunnan Province, China. The SHASEA project adopted holistic and multidisciplinary approach to implement project activities. The basic research was conducted in research station and applied research under farmers' field condition (SHASEA, 2003). Thus, the innovation system of SHASEA Project was similar to the FSR/E approach and *Model I* of FPR approach (Cornwall *et al.*, 1994). Most of the cultivable land in Kelang village was located on sloping uplands (approx. 80%), where fairly intensive cultivation was being practiced (Kelang Village Authority, 2002). Soil erosion from the cultivated land was a common problem. In this context, Kelang village was selected as the Project site.

9.1.1 Socio-economic situation of Wang Jia catchment, Kelang village

Kelang village is a fairly an old establishment. The village has most of the basic development infrastructure, such as road links to other cities and towns, a hospital, a school, water supply, electricity, telephone, market and some Government offices.

From a geomorphopedological perspective Wang Jia represents a typical upland catchment and from the socio-economic perspective Kelang village was considered as a fairly typical rural village in Yunnan Province (Fullen *et al.*, 2002). Subsequently it was found that, unlike in other villages in the locality, the dependence on agriculture for household income in Kelang village was decreasing and the livelihood strategy of the farming household was shifting from on-farm to off-farm activities. This change in livelihood strategy was possible because of good opportunities for off-farm employment both in Kelang and in Kunming, the nearest city (SHASEA, 2003). Not many villages have the same level of off-farm employment opportunity. So despite the initial perception of being one of the typical rural villages of Yunnan, Kelang may not be as representative as was first thought and this may pose a limitation on generalisations that can be drawn for the surrounding region. Enthusiasm and commitment of the households to farming may be an important factor for the adoption of more sustainable cropping practices.

9.2 Effectiveness of the SHASEA Project in relation to its own scientific objectives

The SHASEA project was implemented at a catchment scale with the twin objectives of (i) increasing productivity and (ii) achieving this in a more sustainable and environmental-friendly way (SHASEA, 1997). **INCOPLAST** (*Integrated Contour Cultivation, Polythene and Straw Mulch Treatment*), was designed as an innovative practice to achieve both objectives – increasing productivity and sustainability. The latter was also addressed through additional measures at catchment level. In all, seven agricultural technologies and development interventions were tested/introduced in the Project catchment (Table 9.1), together with a number of engineering measures.

Table 9.1 Agricultural technologies/development interventions tested and extended in Wang Jia Catchment, 2002.

S No	Technologies	Remarks
1	Polythene mulching	Existing technology: but mostly used in tobacco and vegetable production. The Project tested and extended this technology in order to reduce soil erosion and increase maize productivity.
2	Straw mulching	Technology new to the area: The Project tested and extended this technology in order to increase soil quality and maize productivity and to reduce soil erosion.
3	Irrigation	Existing technology: but with very low access, particularly in the upland areas. The Project tested and extended this technology in order to increase crop productivity, extend the cropping season during drought periods and reduce crop failure during droughts.
4	Contour cultivation	Existing technology: but not widely practised, as traditionally farmers have cultivated using downslope cultivation practices. The Project tested and extended this technology in order to reduce runoff and soil erosion and thereby conserve soil resources preventing productivity decline.
5	Inter-cropping	Existing technology: but adapted by farmers to suit their condition and need, which were different to the recommended intercropping practice. The Project tested and extended improved intercropping technology in order to increase overall crop productivity and economic return.
6	Use of grass strips	Technology new to the area: The Project tested and extended this technology on a small scale in order to reduce runoff and soil erosion and to increase organic matter inputs.
7	Tree planting	Existing technology: The Project extended this activity as an ecologically and economically suitable alternative in sloping areas where the gradient is >25°.

There was a good mixture of researchers and development agents in the Project team from local organisations to European institutions. As far as the Project team was concerned, the farmers did what was required and their participation in the SHASEA project was limited to consultation and participation in training and field days. The 1990s decade witnessed a shift in the working approach of development assistance organisations from the top-down approach to a participatory process (Fukuda-Parr *et al.*, 2002). However, the farmer participation in SHASEA Project was not robust. There were extensive discussions with village and township leaders. However, effective communication between local and foreign partners was limited by the language barrier.

Agricultural systems that involve farmers in experimentation and evaluation are more progressive than those which prescribe instructions (Uphoff, 2002).

The Project was successful in achieving its stated scientific and technical objectives. In summary, the successful outcomes were:

- Novel and modified cropping practices have been evaluated, including INCOPLAST, which can increase yield for maize by up to 50%, compared to traditional methods.

- Land management plans have been developed to achieve a more sustainable agricultural system in Wang Jia Catchment.

- Comprehensive surveys and descriptions of the biophysical characteristics of the catchment have been completed, which have provided a baseline for subsequent change and established the representativity of the catchment in relation to the surrounding area.

- Socio-economic analysis was carried out to determine the economic and social feasibility of the alternative cropping strategies, the wider implications of the land use changes and the likelihood of subsequent adoption and adaptation of the technologies employed. Moderately long (five years plus) perspectives are needed for investment programmes to yield dividends.

- Scientific evaluation of selected cropping practices developed in Wang Jia has been carried out in North Thailand and has demonstrated that these practices are, in most respects, as effective as the best practices in use in that region.

- Dissemination and training activities for wider adoption of these practices and associated recommendations have been initiated.

- Scientific training associated with the project outcomes has been achieved through a series of undergraduate, Masters and Ph.D. programmes.

- Dissemination of the scientific outcomes of the Project has been achieved through presentations at a number of national and international conferences, a scientific tour of the catchment, a provincial workshop held at YAU and a series of publications and reports.

Initial uptake was monitored by the Project team in the final year of the project. There was comparatively high initial uptake of polythene mulch, contour cultivation, sweet chestnut and intercropping technologies in Wang Jia during the first year after the Project intervention. Polythene mulch for maize was used in more areas in the catchment compared to neighbouring areas. Similarly, the use of contour ridges was greater in the catchment than surrounding areas. The longer-term actual contribution of these technical achievements to improved productivity and sustainability depends on the extent of future adoption/adaptation of these technologies by farmers. Farmers' attitudes towards a technology have a strong influence on whether or not they intend to adopt it (Garforth *et al.*, 2004). Farmers' perceptions and their future intentions about the adoption of project technologies are important to translate scientific demonstration of effectiveness into increased productivity, higher household incomes and improved conservation and sustainability in the catchment.

Planning and implementation of an adaptive project is completed in four phases (experimental, pilot, demonstration and replication projects) to address the problem in experimental, incremental and adaptive ways (Rondinelli, 1993). The SHASEA Project, however, completed only the first two phases.

Farmers' perspectives and their views on the adoption/adaptation of the practices introduced by the Project are discussed in the following sections.

9.3 Effectiveness of the SHASEA Project technologies as perceived by farmers and stakeholders at the end of the Project

9.3.1 Effectiveness of project technologies

9.3.1.1 Contour cultivation

Farmers perceived contour cultivation as one of the most preferred and appropriate technologies for Wang Jia catchment. This was manifested by the preference of a high proportion of farmers for contour cultivation in household interviews, group discussions and discussions with Key

Informants. Farmers perceived that the area under downslope cultivation was diminishing over time and the area under contour cultivation practices was increasing (Table 6.5). Downslope cultivation was considered to be easier, less time consuming and thus requiring less labour compared to contour cultivation (Table 6.9).

Contour cultivation was perceived to be easier than downslope cultivation for irrigation, fertilisation and harvesting, while downslope cultivation was perceived to be easier than contour cultivation for weed control, earthing up, covering polythene and draining excess water from the field (Table 6.7). Furthermore, contour cultivation was perceived to have more favourable effects on production compared to downslope cultivation, as soil, water and nutrient losses were thought to be higher in downslope cultivation resulting in inferior crop performance and crop yields (Tables 5.6 and 6.8). Several published works reported similar results (Neal, 1963; Bhatia and Choudhary, 1977; van Keer *et al.*, 1998; Gangcai Liu *et al.*, 2000; Poudel *et al.*, 2000; Milne, 2001; Barton *et al.*, 2004; Shi *et al.*, 2004). High weed population and increased tendency of lodging were the only perceived disadvantage of contour cultivation. Considering the popularity of traditional downslope cultivation in Yunnan, adoption of contour cultivation technology will be more widespread only after considerable efforts on the dissemination of the technology or ways to be found to convince farmers of its importance in reducing soil losses. Various authors have stressed the need for more access to information for farmers, more dissemination activities and demonstration of clear benefit from the technologies in order to improve the uptake and adoption of soil and water conservation technologies by farmers (Fujisaka, 1991; Ruaysoongnern, 1999; Tang Ya, 1999).

9.3.1.2 Mulching

Two types of mulching technologies (polythene mulch and straw mulch) were evaluated in Wang Jia catchment. Farmers preferred polythene mulch as they perceived that it improves seedling emergence, increases crop production and conserves soil, water and soil fertility (Tables 5.16 and 6.16). Insufficient soil moisture during winter, spring and early summer season often results in poor crop establishment in South West China (SHASEA, 2000). Polythene mulch conserves soil moisture by reducing evaporation losses particularly during the dry season (Zhang YongTao *et al.*, 2000 as cited by Wang ShuHui, 2003; Li YongMei, 2004). In addition, polythene mulch increases soil temperature during early spring and winter, when soil temperature remains particularly low (Barton, 2000; Wang ShuHui, 2003). Thus use of polythene mulch favours early crop establishment and increased crop yield (Barton, 2000;

Huang BiZhi, 2001; Wang ShuHui, 2003). This could be the reason why farmers perceived '*improvement in seedling emergence*' and '*increase in crop production*' as the most important advantages of polythene mulching (Table 6.16). Farmers, however, wanted to use polythene mulch particularly for high value crops, which ensure a higher return for the purchased polythene. So despite the high preference of farmers, it may be unrealistic to expect significant adoption of polythene mulch for maize. Moreover, the adoption of polythene mulch could be limited among poorer farmers because of the cost associated with the use of this technology.

Straw mulch did not appear as a farmer-preferred technology. Initial uptake of straw mulch technology by farmers was low (Tables 5.9 and 6.10). Use of straw mulch increased the maize yield, maintained soil moisture and reduced moisture losses from the soil during the drier period (Lal, 1974; Aina, 1981; Wu XingMing, 1990; Gajri *et al.*, 1994; Wang ShuHui, 2003). Farmers were aware of the advantages of straw mulch technology (Table 6.15). However, the low uptake was mainly due to the low availability of straw for mulching (Table 5.10). Farmers preferred to use straw for feeding livestock, so it is less likely that farmers will use straw for mulching until production exceeds their requirement for animal feed. Non-availability of material inputs is one of the frequently quoted reasons for low uptake (Garforth, 1998). Any future endeavour in promoting straw mulch in this area must consider increasing the production of straw. Straw mulching was not a traditional practice for farmers in this area. Farmers were not enthusiastic about increasing the area under straw mulch (Table 6.13).

Cost-benefit analysis of mulching revealed, however, that polythene and polythene + straw mulching were both economically profitable options for maize. The net income from both of these mulching options exceeded no mulching, by 945 Yuan/ha (Table 8.22).

9.3.1.3 Intercropping

Farmers in Wang Jia catchment practised intercropping in a traditional way by mixing a low density of companion crops within the main crop. However, the area under the recommended intercropping practice was very small (Table 5.17). Farmers were reluctant to use these alternative intercropping practices. The soybean variety introduced by the Project team for intercropping failed to produce pods and hence grain yield in one season, so it may not have been suitable for Wang Jia catchment. This could be the reason for the farmers' reluctance to use this particular practice (Table 6.19), although cost-benefit analysis of intercropping revealed that maize/French bean intercropping was more profitable than monoculture maize by 735 Yuan/ha

(Table 8.23). Clear effectiveness of the potential technology is one of the important conditions for the uptake and adoption of the technology by the farmers (Ruaysoongnern, 1999; Neupane *et al.*, 2002). Similarly, Garforth and Usher (1997) reported that appropriateness was the most commonly cited factor for the uptake of the research outputs.

9.3.1.4 Tree planting

The tree planting strategy tried to comply with Government policy and at the same time take advantage of the export potential of the selected tree products. Land with >25° slope angle was selected for planting, consistent with Government policy (Tang Ya *et al.*, 2003; Zhu Xioke, 2003, *pers. comm.;* Shi *et al.*, 2004). Planting sweet chestnut in the lower part of the catchment and prickly ash in the upper part were profitable income generating options for the farmers. The differing locations took into account the differing environmental requirements.

Farmers liked both the tree planting strategy and the species selected for planting in Wang Jia. However, despite their preferences, farmers were reluctant to adopt the technology due to their small land holdings and competition between trees and crops resulting in low crop yields before any income benefits materialized (Tables 5.22 and 6.21). Farmers preferred those technologies that gave quick returns, or met family food requirements. Farmers were concerned about the long-term nature of investment in tree planting. Moreover, the initial six years would be difficult for the poorer sections of the village (Table 8.29). Thus any expectation of wide adoption of tree planting by smallholders would be unrealistic, unless the tree-planting programme is accompanied by either subsidy provision for the initial six years, or suitable quick income-generating options. Adoption is more likely among richer farmers, who have good economic buffering capacity. In Nepal, small landholders were hesitant to accept new technologies which take time to produce a return, despite their potential to earn higher a income than the existing practices over a longer time period (Neupane *et al.*, 2002).

The tree planting strategy was developed by the township and village Leaders. All the decisions regarding the plantation area and tree species were taken by local researchers of the Project and leaders of the township and village. Farmers were not involved in the decision-making process. However, addressing poverty using agro-forestry interventions is not possible just by considering biophysical issues. The effects on soil fertility and rural livelihoods are mediated by socio-economic factors (Garforth *et al.*, 1999). The socio-economic factors and farmers' concerns could have been better addressed if farmers had been involved in the process.

9.3.1.5 Irrigation

Considering the capacity of the system, the use of irrigation was low in terms of both number of users and area irrigated (Tables 5.26 and 5.28). There was a need for the irrigation system, local leaders were committed to the scheme, field trials established the benefits of using irrigation, but despite all these positive attributes, many farmers did not use irrigation. A possible reason could be the cost, which was more than the anticipated benefit from production (Wu Bo Zhi, 2002, *pers. comm.*). Farmers in upland areas of Yunnan either use polythene pipes or carry the water on their shoulders to irrigate fields, which is a difficult and costly method of irrigation, particularly for field crops. Contrary to this finding, small-scale irrigation schemes have been more successful in other regions, for example in tropical Africa (Okigbo, 1990).

Farmers said they were willing to contribute to the future maintenance, management and use of the irrigation system. However, these responses did not accord with their current practice. This was probably because they were anticipating changes in cropping systems in future. They considered that maize might be replaced by income-generating crops, such as tobacco, vegetables, flowers and fruit trees. This indicates that farmers did not want to use extra resources in irrigating low value, high volume crops, like maize and wheat, but they wanted to have irrigation available for more profitable high value crops in the future. Since the project objectives were to use irrigation to increase productivities of maize and wheat, this approach was not successful in the catchment as a whole.

9.3.2 Effectiveness of training and dissemination activities of the Project

9.3.2.1 Training

Training activities were conducted primarily for the farmers within the Project area. The Project did not implement a gender or wealth-differentiated training programmes. Most of the farmers across the gender and wealth categories had access to the training programmes (Tables 5.32, 6.27 and 6.28). Training activities were organised twice a year (once during the maize growing season and another time during the wheat growing season). This would have been more effective if short training sessions had been organised at different times of the season when particular technologies could be used in the farm in real life situations. Training based on real life material and situation has been described as an effective means of training delivery (Edwards and Farrington, 1993).

Examples were found which indicated that there was a need for more training. Farmers were found to adopt technologies inappropriately in Wang Jia catchment and the vicinity. For example;

a. A farmer in Wang Jia planted prickly ash trees at a very high density (five times more than recommended). In addition, he planted sweet chestnut trees in the gap between two rows. The trees were planted at different times, so the trees were at different growth stages. At first, the farmer planted few trees and found it to be more profitable. Then he planted more trees in the same land exceeding the recommended density many times.

b. A farmer from Mosu village planted sweet chestnut trees at very high density (three times higher than recommended) (Box 7.2). He was not aware of the improved management technology, so a very poor yield is likely, resulting in economic setback.

c. The practice of the majority of farmers for disposing of used polythene was potentially environmentally hazardous (Table 5.13). Scope for recycling already existed in Kelang village, as some local merchants were buying used polythene (Box 7.1). Farmers' awareness needed to be increased through training and demonstrations, in order to promote the recycling of used polythene.

Inappropriate adoption of technologies by farmers could be because of poor knowledge and information as a result of insufficient extension and training services provided to farmers. Whatever the reasons could be, the benefit from the technology could not be expected when it was adopted incorrectly. The failure of improved technologies to be technically effective and economically profitable in their hands is likely to result in the farmers stopping their use of the technology. So there is a need for more training of farmers in project technologies. Training played an important role in the transfer of sustainable soil management technologies to wider communities in Nepal (Neupane *et al.*, 2002).

9.3.2.2 Dissemination

Dissemination helps in increasing the level and speed of uptake of research outcomes by farmers (Garforth, 1998). Project information was well disseminated within the scientific community via workshops and the publication of Project information in different books, proceedings, posters and pamphlets (SHASEA, 2003). However, Project plans were not explicit in describing how wider dissemination at farmer-level would be achieved.

Information about Project activities was disseminated well within Wang Jia catchment only. This was done by increasing farmers' awareness through training, and by providing material help/compensation to encourage initial adoption (Tables 5.32, 6.27 and 7.5). All the farmers in the catchment had some information about Project activities and status (Table 6.26). Medium and rich categories were more aware than poor category households. Wider dissemination of Project activities outside the catchment and associated training was not sufficient during the first phase of the Project. Further dissemination was planned for the second phase of the Project, which was proposed to the INCO-DEV Programme of the European Union, but did not receive funding.

The SHASEA Project was one of the most important sources of information for improved agricultural technologies during the Project period in Kelang village (Tables 5.33 and 6.30). Farmers also received information about improved agricultural technologies from neighbours and relatives. Garforth *et al.* (2003) mentioned that *'other farmers'* was the most frequently reported source in most of the survey reports, where sources of information were asked of the farmers. Similarly, Subedi and Garforth (1996) argued that farmer-to-farmer diffusion of innovations is important, irrespective of any formal extension intervention. Farmers are more likely to be influenced by other farmers than by extension professionals for their farming practices and management decisions (Garforth and Usher, 1997). For example, farmers in Nepal considered the information from friends, relatives and neighbours to be the most trustworthy source for learning about new innovations (Neupane *et al.*, 2002). This highlights the importance of the farmers' role in information dissemination, which underpins the relevance of strengthening farmer-to-farmer extension systems in the area.

There was inadequate communication between Project researchers and local extension systems regarding the dissemination of Project technologies. Project researchers were not aware whether the extension services had included any Project technologies for dissemination in wider areas or not. Similarly, policy makers had limited information about the Project. This revealed inadequate communication between project officials and policy makers at the provincial level. This would not have been the case if there had been regular contact and communication between concerned stakeholders. Information is not simply passed on but can be continually transformed and adapted through these communication networks (Garforth and Usher, 1997).

After a general briefing about the Project, the Manager of the Soil and Water Conservation Department of Yunnan Province appreciated the Project processes (such as multidisciplinary and holistic approaches, involving farmers in Project activities), technologies and application of scientific approaches (such as installation of a gauging station) to tackle the problem of soil and water erosion in the region. Perhaps wider dissemination of Project technologies through Government extension networks and any policy impacts would have been greater if the team had established regular communications with such networks. Dissemination tends to be more complex than just technology generation and verification because it involves more stakeholders, so a multi-partnership approach, with a central role for farmers, was found to be a more suitable approach for technology dissemination to farmers in Nepal (Joshi *et al.*, 2002).

Discussion with farmers revealed that the use of some technologies was influenced by the type of crops grown. Irrigation was more widely used for tobacco than for maize. This was because of the higher return from tobacco compared to maize. Similarly, downslope cultivation was preferred where tobacco was grown in order to drain excess moisture quickly, because of the susceptibility of tobacco to high moisture conditions. Similarly, some technologies, particularly polythene mulch and irrigation, were more popular among the farmers outside the catchment compared to those within the catchment. This was because maize was grown as the main crop in the catchment, while tobacco was grown in large areas outside the catchment. Such variation in production environments requires a basket of technologies suitable for different production niches. There is increasing realisation of the value of a niche-based on-farm approach to technology development and dissemination with varied levels of farmer participation in the programme (Gupta *et al.*, 1996; Atlin and Witcombe, 2002; Paris *et al.*, 2002).

9.3.3 Further feedback from stakeholders

9.3.3.1 Positive comments

Local stakeholders, particularly the Key Informants who were the Leader of Kelang village and extension agents from Kedu Township, mentioned the following points as strengths or good aspects of the project. It is obvious that some of the points they mentioned are based on future expectations, as some of the effects of Project activities had not been fully realised. However, this gives some insights to what local stakeholders perceived as important. This can be treated as the starting point for the planning of similar Projects.

a. The Project changed farmers' perceptions about natural resource management and utilisation. Farmers understood the benefit of conserving natural resources, which reduced over reliance and over-use of forest resources. Deforestation had decreased and farmers had now started to plant trees for themselves. They were now aware of the benefits of soil and water conservation and trying to avoid using those technologies that lead to increased soil and water losses.
b. The check dam in the gully was very effective in controlling soil and water losses and flood frequency and severity in the village.
c. The environmental conditions of the catchment had changed substantially due to Project efforts during the previous 3 years, particularly due to the decrease in soil-water losses and frequency of flooding.
d. The Project had introduced scientific technologies and training programmes to farmers about improved cultivation practices. In the past, farmers used to practice downslope cultivation over large areas in the catchment. Now farmers knew the benefit of contour cultivation and the area under contour cultivation was increasing.
e. Crop productivity in the catchment had increased. In the past, farmers used to give less attention to the catchment. The Project mobilised farmers to try improved technologies on their land. Consequently, farmers were giving more time to farming activities in the catchment and investing more inputs, particularly manure and fertilisers. As a result, crop productivity had increased.
f. Kedu Township was planning to extend some of the Project technologies to similar areas. In particular, the following technologies were being considered for inclusion in extension programmes:
   - Grass strip technology;
   - Tree planting on land with $>25^0$ slope (this is also one of the strategies of the Government of China to address the problem of soil and water erosion in highland areas);
   - Contour cultivation technology;
   - Polythene mulch technology;
   - Construction of dams in the gullies of similar catchments.

On the downside, the Leader of Kelang village mentioned there were too many surveys and too many questions asked by the Project staff. Often the same questions were asked repeatedly. This demanded substantial time of both farmers and researchers and should have been reduced.

9.3.3.2 Suggestions for the future

Suggestions were sought from different stakeholders, particularly the Key Informants, Leader of Kelang village, extension agents from Kedu Township and policy makers from the Provincial authority. The suggestions of the stakeholders pointed out three major issues that needed to be considered in future research and development interventions.

a. In their view, it would be better not to plan and implement long-term initiatives if the Project duration was short. Most of the stakeholders were concerned about possible damage to the rehabilitating environment, particularly the growing trees. Alternatively a clear plan should be developed for protecting such features after Project completion, which might include the provision of financial resources.
b. The stakeholders identified the need for wider dissemination of Project technologies. They also pointed out the need for extension materials, such as pamphlets, posters and radio programmes, in order to achieve wider adoption of Project technologies by farmers.
c. Similarly, stakeholders pointed out the lack of training opportunities for the farmers outside the catchment. More training was perceived as important in order to enhance and widen adoption of Project technologies.

9.4 Impact analysis

9.4.1 Environmental impact of Project activities

9.4.1.1 Effect of Project technologies on natural resources

Farmers appreciated the Project's activities aimed at increasing forest and water resources and soil fertility, and decreasing soil and water losses from the catchment. They presented a number of reasons for the beneficial changes in the environmental conditions of the catchment. This indicates that they were aware of the benefits of the Project activities, although the magnitude of the changes perceived by farmers was greater than anticipated by the Project team. In a similar way, farmers in India also appreciated soil and water conservation projects, implemented in Gujarat, Rajasthan and Madhya Pradesh, for favourable impacts on crop productivity and cropping systems, soil erosion and environment, social and economic concerns (Smith, 1999).

9.4.1.2 Farmers' practices for soil and water conservation

Farmers' existing practices for the control of runoff and soil loss were similar to the Project's improved practice. The farmers' practice, however, relied more upon locally available resources (such as wood, stone and sand) to implement smaller actions at plot level and this was different to the Project's approach, which used purchased materials (such as cement and steel) to implement large scale activities at catchment level. A study conducted in Thailand reported that the farmers' practices of soil and water conservation were similar to those of the improved technologies introduced by development agencies and farmers were familiar with the concepts of those technologies (Ruaysoongnern and Patanothai, 1991).

9.4.1.3 Recycling of polythene used for mulching

Despite considerable use of polythene mulch, farmers were less aware of the environmental pollution due to polythene, particularly when not collected and disposed of properly after use. Some farmers collected the polythene used mainly in tobacco production and sold it to a local merchant in Kelang village. Only a small proportion of polythene used in maize was recycled, due to difficulties in collecting from the field and cleaning the polythene. Studies showed that if the polythene mulch was used for three years, ~37.5 kg/ha of polythene would accumulate in the soil. Accumulation of polythene in the soil at 45 kg/ha, decreased vegetable yield by 2-10%, which could be due to negative effects on plant rooting and water movement in the soil profile (Li Xiaoyun *et al.*, 1997). The accumulation of polythene in farmland has been termed '*white pollution*' in China (Huang BiZhi, 2002, *pers. comm.;* Wu Bo Zhi, 2002, *pers. comm.;* Li YongMei, 2004). The SHASEA Project's effort to reduce such '*white pollution*' was not sufficiently effective. Two-thirds of farmers in Wang Jia were still practicing environmentally hazardous methods for post-use collection and disposal of polythene from farmland (Table 5.13). This indicates that there is a need for identifying more effective training methods for increasing farmers' awareness of white pollution and motivating them to practise environmentally friendly methods to minimise the negative effects of polythene accumulation on farmland. This aspect needs to be taken into consideration in the future, while designing programmes for the dissemination of SHASEA results. In addition, any endeavour to extrapolate the result of polythene mulch technology must consider this aspect and design the programme in order to minimise the hazardous effects of polythene on the farming system.

9.4.1.4 Effect of project activities on environmental conditions of the catchment

9.4.1.4.1 Farmers' evaluation

Farmers concluded that the environmental condition of Wang Jia catchment was better than the adjacent Lai Zi catchment (Table 6.39). The overall responses of the farmers focused on five major aspects, viz. a) current situation of soil and water losses, b) vegetation cover and natural resources, c) infrastructures and catchment management, d) use of environmentally friendly technologies, and e) crop performance and productivity. The involvement of local user groups in the monitoring and evaluation of spatial and temporal changes in the catchment can be beneficial to both local users and researchers; for local users, it may help in improving land literacy (the ability to identify and appreciate good/bad conditions) about the catchment; and for researchers it would provide less expensive and quick information about complex natural resources management issues compared to conventional approach requiring large and expensive sets of information (Ravnborg, 1996).

The farmers of Kelang village were highly capable of evaluating environmental changes in the catchment using scientific indicators. This indicates their potential to work in collaborative ventures for soil conservation and catchment improvement. However, they were found to be very reluctant to point out the weaknesses of the Project, and very reserved and hesitant to provide critical comments. Farmers could not envisage the importance of their responses and hence did not try to articulate their responses for their own benefit. This was because farmers in China have a habit of working with the top-down approach of the Government and there was no training and orientation programme in participatory approaches designed for farmers in the Project. So, any such research and development programme should start with an orientation on participatory approaches in order to consolidate meaningful contributions from farmers.

9.4.1.4.2 Politician and extension agents' evaluation

The leaders of Kelang village mentioned that the check dam in the gully was very effective in controlling soil and water losses, as a result the frequency and severity of flooding had been reduced in recent years. They perceived that the environmental conditions of the catchment had improved substantially due to these developments being implemented through the Project. The off-site (downstream) effects of Project activities could favourably contribute in reducing the environmental damage along the Yangtze River, as soil erosion not only affects the local area, but also vast areas downstream (D'haeze *et al.*, 2005).

9.4.2 Social impact

The leader of Kelang village said that the Project had changed farmers' perception about natural resource management and utilisation. Farmers now had a greater understanding of the benefits of conserving natural resources, which reduced over-reliance and over-use of forest resources. For example, deforestation had decreased in recent years and farmers were now starting to plant trees in crop lands. They were trying to avoid using the practices that lead to increased soil and water losses. In a similar notion, extension agents in Kedu Township also mentioned changes in local perceptions about the environmental conditions in Wang Jia after the Project implementation. In particular, the reduction in flood incidences was having a significant impact on the village.

9.4.3 Impact on human resource development

Fifty-four students (47 Chinese and 7 European) received postgraduate research opportunities from the SHASEA Project. Four Chinese researchers received (one in progress) an overseas academic degree, of which three were female. This helped to train Chinese researchers in European academic institutions. An additional twelve Chinese students conducted experiments in the SHASEA Project for their undergraduate degree. Similarly, the SHASEA Project produced a considerable number of publications; most of them, however, are not in the public domain (SHASEA, 2003).

9.4.5 Impact on women

The Project did not have any gender-differentiated activities. Any participation of female farmers in Project activities was incidental. There appeared to be higher aspiration among male members in Kelang village to get involved in off-farm activities. This was apparent from the fact that 63% of women in the village worked full-time on the farm, while only 22% of men did so (SHASEA, 2003). This had increased the role of women in farming activities. In this situation, any contribution of Project activities in increasing household income and reducing drudgery would help women more than men. Projects implemented with participatory approaches tend to improve the participation of women in Project activities decision-making processes (Smith, 1999). This can lead to positive change in the way women are viewed by society.

9.5 Other strengths/weaknesses of the Project

9.5.1 Strengths

9.5.1.1 Working to the local government agenda

One good aspect of the SHASEA Project was that it attempted to address a priority issue of the local Government by embedding the regional priority of improving maize-based cropping systems into its main research and development agenda. International development schemes have been criticised for imposing their own research/development agendas on host countries/organisations rather than solving the problem(s) identified by the host countries/organisations themselves. Funding and technical assistance agencies tend to adhere to their own interests, priorities and procedures (Samoff, 2004).

9.5.1.2 Working with existing local research and development networks

The research team comprised a balanced mixture of subject matter specialists from European partner institutions and development experts from local Government institutions of the host countries (China and Thailand). The involvement of local extension agents and political leaders in the research team facilitated the integration of Project outputs into the existing Government structure for information dissemination. Effectiveness of the dissemination can be increased when it is done through the existing structures (Garforth, 1998; Joshi *et al.*, 2002).

9.5.2 Weaknesses

9.5.2.1 Lack of participatory approach

The participation of local stakeholders in most of the Project processes and activities was limited to local researchers, extension agents and local political leaders. Farmers were not actively involved in planning and decision-making processes. Generally, farmers were informed later about decisions on Project activities. This did not create a problem in implementing the Project; however, lack of orientation of farmers in participatory approaches and actions resulted in poor communication and understanding between farmers and Project personnel. For example:

a. *Farmers' hidden agenda about irrigation:* The irrigation system was not originally planned by the researchers. This activity was added later upon the demand of the local stakeholders. Group discussion revealed that farmers were happy to have the irrigation system in place, but the use of irrigation was very limited during the entire Project. Subsequent discussion with Key Informants revealed that farmers wanted the system for more profitable crops, like tobacco or vegetables, which require irrigation. Better communication and understanding between farmers and researchers would have been established if farmers' participation had been sought earlier in Project processes and activities.

b. *Chinese tradition and farmers' response attitude:* Farmers were very hesitant to mention weaknesses and limitations of the Project. Despite the request to put forward Project weaknesses (which would provide a basis for future improvement), farmers tried not to give any negative responses, particularly when the matter was discussed in groups (possibly in front of outsiders/foreigners). During group discussions, farmers mentioned only those points that they thought researchers would like to hear. For example, farmers said 'the quality of crops has increased because of the irrigation' despite the fact that the use of irrigation was very limited. Moreover, the degree of adoption of Project technologies that was estimated during group discussion was in general greater than estimates made during the personal interviews in the household survey. As a result, farmers' responses during the PRA exercise were more positive than in the household survey and individual discussions. At least some weaknesses of the Project's activities were mentioned in the household survey. This could be due to lack of experience of farmers in participatory approaches. Song (1999) reported that a participatory approach was introduced in rural development projects during the early 1990s in China. However, the concept of participatory action was new to farmers and village officials in Kelang village. The farmers were *au fait* with the top-down approach of the Government. Thus, triangulation (use of information from different sources to draw conclusions) became necessary for information collected in a group exercise like PRA.

   Farmers usually gave credit for production increases to better seed quality, whatever the real reason for increases in crop production. This was the traditional way of thinking for the farmers, even though they realised other factors were also responsible for the increase in productivity.

c. *Discrepancy between response, commitment and action:* Discrepancies in farmers' responses (in terms of their willingness to adopt or their estimation of future adoption) and actual actions were observed in some cases. For example, farmers highlighted the benefit of irrigation, but only a few used it. Similarly, farmers praised the Project for protecting the catchment and implementing conservation activities that improved the environmental conditions of the catchment. They also said the Project approach and farmers' approach to soil and water conservation were similar, but they themselves were excavating two of the hilltops in the catchment for rock extraction. This increased the risk of soil erosion and landslides on such steep slopes.

9.5.2.2 Appropriateness of subsidy - subsidy, orientation and farmers' attitude

Subsidy, in the form of free inputs and labour compensation, was provided to farmers to promote implementation of Project technologies, but due to the lack of a participatory approach, there was not enough understanding about these subsidies. The objectives of the subsidy and duration of subsidy were not discussed sufficiently with farmers. This increased farmers' expectations for subsidy from the Project. Moreover, farmers' over-estimated the input used by them (Liu HongMei, 2002, *pers. comm.*). The input data provided by farmers was much greater than data from the plot experiment (actual data, Wang ShuHui, 2003). Farmers might have deliberately over-estimated the inputs, expecting to receive more subsidies. Project researchers also perceived that this was one of the reasons for over-estimation of input costs by farmers.

9.5.2.3 Unrealistic ambition

Improving cropping systems and environmental conditions at catchment level are potentially longer-term activities. Similarly, it takes a longer project duration to realise the benefit from some technologies, like tree planting at household level. Despite having such longer-term objectives on board, the Project was planned for a short duration (three years), following EU guidelines. Considering the tendency of slow changes in agricultural systems, Hudson (1991) suggested a 10-year horizon for soil conservation projects as a norm. This was a weak aspect of the Project.

The trees in the catchment were still young and vulnerable to damage from livestock at the end of the Project. They needed to be protected for some time until acquiring greater height and girth. Rehabilitation of gullies was in progress, which could suffer a setback if the protection of the catchment was discontinued. Farmers had experienced a reduction in flood incidences, but had not been able to see changes in vegetation cover and their effect on soil-water losses and the local hydrology of the catchment. Farmers would be convinced about the benefit of Project activities and soil-water conservation only if they had the opportunity to see them in the field. This could be instrumental in persuading farmers and extension agents to extrapolate the practices elsewhere. Moreover, the main phase of the Project had invested in the evaluation of the technologies in the catchment and was already completed by December 2002. Wider dissemination of Project technologies and farmer training had been planned for a second phase; however, the Project team's application to the European Union (EU) for an extension of the project was not successful. Thus, the Project came to an end, having completed planned short-term activities but without achieving longer-term objectives. This has two implications:

a. The delivery of benefits of the international development programme to target group(s) remained incomplete. This reduced the effectiveness of the programme.
b. Farmers were experiencing the outcomes of the first international development assistance to be implemented in the area. If the environmental condition of the catchment returned to its pre-Project condition and if farmers did not realise any benefit from Project technologies, then they might develop a negative perception of international development programmes. If this happened, it might be difficult to gain their participation and co-operation in future development projects.

A longer-term commitment was essential to achieve Project objectives. Adequate and continuous funding has been identified as one of the important factors responsible for the success or failures of the project (Ruaysoongnern, 1999). However, the restrictions imposed by the EU Framework Programme meant that the project was implemented for a short duration only. It was assumed that the host institutions would continue Project work after the first phase of the international co-operation funded by the EU. This was the rationale for funding long-term Projects for a short duration. At the local level, however, there were no effective plans to continue the Project work, as assumed by the funding agency. Instead there was an expectation for further funding for the Project from the funding agency. Thus, it may be an appropriate time to review whether such assumptions work in real life situations and what may be needed to improve the effectiveness of such international co-operation. These are some of the issues which funding agencies, such as the EU, should consider to enhance international co-operation.

9.6 Other issues related to adoption of Project technologies

9.6.1 Size of land holding vs. adoption of improved technologies

Farmers in Wang Jia were reluctant to invest extra resources (labour and money) to reduce soil and water losses, improve soil fertility and maintain crop productivity if total household income was not increased. Most farmers have a small and fragmented landholding (Table 3.6, Chen, 1992; Fleisher and Liu, 1992 as cited by Guang and Enjiang, 2000), thus only a small proportion of their total household income comes from the catchment. Therefore, they are less interested in carrying out extra work to achieve a relatively small increase in their total income or to improve soil conservation. Under these circumstances, if they continue with their traditional cultivation practices, land quality will keep deteriorating with time and hence crop productivity will decline along with financial returns. However, farmers neither agreed to give up cultivating their land nor improve its condition. This indicates that simply demonstrating technologies that improve productivity or soil conservation may not be sufficient. More proactive measures may be required to achieve more extensive adoption. A suitable solution to this situation is perhaps beyond the reach of a Project such as SHASEA- such solutions have to be addressed by national policies.

In China, land fragmentation occurred as a result of the reform in production systems from collective to household production systems during late 1970s (Chengri Ding, 2003). As a result agricultural production increased substantially during the initial years of reform, reaching its highest level in 1984, but this success was not sustained for longer periods (Sanders, 2000). Small scale production was one of the reasons for the low economic profit of crop farming; as a result the sustainability of crop production was negatively affected (Li, 1995 as cited by Sanders, 2000).

9.6.2 Land security vs. farmers' stewardship towards land resources

Land rights in China are still incomplete as the trading of land in rural China is forbidden and farmers only have user rights (Guang and Enjiang, 2000). Farmers still lack a sense of land security. More than 40% of farmers in Kelang village thought that the Government would take back their land. Similarly, >25% of households were not aware of the allocation of land to farmers for 30 years. Effective stewardship of land resources will be difficult to achieve in practice while insecurity and ignorance about land tenure exist among the farming community. For example, farmers in Vietnam changed their farming practice to perennial crops in response to the introduction of long-term land security (Phien and Tu Siem, 1997).

9.6.3 Awareness vs. adoption

Initial adoption/adaptation of Project technologies was influenced by farmers' awareness of the technology. Farmers had inadequate knowledge about some of the Project technologies, the adoption of which was particularly low. This reveals the need for increasing farmers' awareness about the rationale for Project technologies to achieve greater adoption/adaptation of project technologies by farmers over wider areas. Adoption of Project technologies by farmers was studied by considering the four conditions illustrated in the following diagram (Figure 9.1).

Out of seven technologies/development interventions tested/introduced, one (grass strips) was a new intervention for the region, while farmers were aware (though at varying levels) of the other six interventions. The adoption of interventions with the least awareness was low.

Four conditions of technological awareness and adoption:

Condition 1: Farmers know and they practice.
Condition 2: Farmers know but they do not practice.
Condition 3: Farmers do not know but they practice.
Condition 4: Farmers do not know and they do not practice.

		Awareness of the technology			
		High	**Medium**	**Low**	**No**
Adoption	**High**	**1b** **3b**	**5a**		
	Medium	**4**			
	Low		**7**	**5b**	
	No	**1a** **3a**			**6** **2**

Note:

Symbol	**Technologies**
1a	Polythene mulching for maize
1b	Polythene mulching for tobacco
2	Straw mulching
3a	Use of irrigation for maize
3b	Use of irrigation for tobacco
4	Contour cultivation
5a	Inter-cropping (farmers' existing practice)
5b	Inter-cropping (recommended improved practice)
6	Use of grass strips
7	Tree planting.

Figure 9.1: Conceptual diagram to illustrate farmers' awareness and adoption of Project technologies/development interventions in Wang Jia Catchment, 2002.

The following descriptors in Table 9.2 were used to work out the conceptual model of awareness vs adoption matrix presented in Figure 9.1.

Table 9.2 Descriptors used in Figure 9.1.

Levels	Descriptions
Awareness	
High	Very good understanding about the technologies/interventions. Individuals in this category are not only aware of the advantages/disadvantages of the technologies/interventions, but they possess very good understanding about the impact of such technologies/interventions on various interacting biological, socio-economic and environmental factors.
Medium	Good understanding about the technologies/interventions. Individuals in this category are aware and hence can articulate and appreciate the advantages/disadvantages of the technologies/interventions.
Low	Some understanding about the technologies/interventions, but often show ignorance and hesitate to discuss the technologies/interventions due to incomplete understanding.
No	Poor and often wrong understanding leading to negative perception about the technologies/interventions. Individuals in this category articulate wrong and negative perceptions about the technologies/interventions.
Adoption	
High	Continuous adoption in substantial proportion of available areas, often in commercial scale (in case of production technologies/interventions).
Medium	Continuous adoption in ~50% of available areas.
Low	Occasional adoption in ~25% of available areas.
No	No adoption.

Muhammad *et al.* (2001) studied the level of awareness of improved sugarcane technologies and adoption by farmers in Pakistan. There was very poor adoption of improved sugarcane technologies where farmers' awareness of the technology was low. Kassioumis *et al.* (2004) also found lack of knowledge to be one of the most important reasons for not adopting tree planting in Greece. Poor access to improved knowledge was one of the important factors for land degradation in Nepal (Neupane *et al.*, 2002). Similarly, education and training greatly increased the likelihood of adoption of soil and water conservation practices by farmers in Burkina Faso (Sidibe, 2005). The adoption process comprises five stages, i.e., awareness, interest, evaluation, trial and adoption (Rogers, 1962 as cited by Enters, 1997). Farming households go through these five stages before making any decision about the adoption of new farming technologies. This is a decision-making process and the adoption of new technology can be discontinued at any time based on the farmers' decision at any of these five stages (Enters, 1997). This theory identifies that farmers' awareness is the first key stage to adoption of new technology by the farmers.

There is a tendency of projects to skip the first two stages of the adoption process and this results in having to persuade farmers at the evaluation stage. This can result in high initial adoption followed by widespread rejection. For example, more than two-thirds of participating farmers discontinued soil and water conservation technologies extended by the Thai-German Highland Development Programme (TG-HDP), when farmers found that the technologies did not work as explained by the Project team (Enters, 1997). Farmers were not aware that soil and water conservation technologies take time to produce beneficial effects, so they could not exhibit superiority over farmers' traditional practice within a short timeframe.

Cruz (1997) reported on the importance of the contribution of awareness in the adoption of soil conservation measures in the upper catchment of the Phulangi River Basin in the Philippines. Enthusiasm of farmers about the importance of hedgerow systems in controlling soil erosion, improving soil fertility and increasing crop production was increased due to increased awareness as a result of an education programme adopted by the project.

9.7 Effectiveness in relation to other development projects

In this section the SHASEA Project is compared with similar projects implemented in South East Asia. The objectives, activities, duration and achievements of different projects were studied. The comparison is based on available information about the other projects, which was collected from various sources.

9.7.1 Achievement of project objectives

The SHASEA Project was successful in completing the planned activities and achieved its scientific objectives. Despite this success, early indications are that the adoption of Project technologies by farmers both inside and outside the experimental catchment will be low. This is a typical situation with soil conservation projects, as other studies reported low adoption of soil conservation technologies by farmers (Fujisaka, 1991; McDonald and Brown, 1999; Saguiguit *et al.*, 1999; Tang Ya, 1999). The real impact of the success in plot studies at catchment level is possible only after the wider adoption of Project technologies by farmers.

There are some initial signs of improvement in the environmental conditions of Wang Jia catchment, but it is too early to claim any lasting improvement in the environmental condition, because changes in the system take place slowly (Hudson, 1991). Moreover, the positive effects of Project technologies on the environmental conditions of the catchment can only be expected if the catchment is protected against free grazing, further deforestation on the upper slopes and more cultivation on the steep slopes.

The Chinese-Swedish Soil Conservation Project was similar to the SHASEA Project in many aspects. Both projects aimed at improving crop production and reducing soil erosion (SUAS, 1991). Both projects were ambitious in setting their objectives as they attempted to study and address the complex issues of cropping systems within a short time-frame (3 years). Hudson (1991) reported that over-optimism of soil conservation projects implemented in Africa was one of the main factors for design-faults leading to project failure.

Longer duration projects, such as the Thai-German Highland Development Programme (TG-HDP) (1981-1998) and the Thai-Australian Highland Agricultural and Social Development (TA-HASD) Project (1982-1993), were successful in addressing more holistic issues than short duration projects like the SHASEA and Chinese-Swedish Soil Conservation Projects (AusAID, 1999b; TG-HDP, 1999).

9.7.2 Effectiveness of technology developed

The final report of the SHASEA Project indicated that the scientific outcomes of the Project were very successful (SHASEA, 2003) and the farmers in Wang Jia endorsed this claim. However, the farmers' reluctance to use straw mulch, the recommended intercropping practices and irrigation have raised some questions regarding the appropriateness of these technologies in existing farming systems. This must raise some doubts regarding future adoption/adaptation of these technologies by farmers. The longer-term effects of Project technologies and development intervention; for example, the effects of contour cultivation on soil fertility and soil-water losses and the impact of tree planting on the environmental conditions in the catchment, have yet to be realised and the outcomes remain inconclusive. This is a classical problem of a short-duration project, which generally achieves considerable success in producing output from activities that can be accomplished quickly but fails to draw meaningful conclusions from activities that require a longer period to mature. For example, the Thai-German Highland Development Programme (TG-HDP, a longer duration project) was successful in improving living standards of the people (TG-HDP, 1999; Dirksen, 2001; Dirksen, 2002). Similarly, another longer-duration project, the Thai-Australian Highland Agricultural and Social Development Project (TA-HASD) achieved all agricultural, environmental and social output targets (AusAID, 1999b), but the short duration projects like Chinese-Swedish Soil Conservation Project and SHASEA could not conclude on outcomes from agro-forestry experiments and environmental objectives were not totally completed (SUAS, 1990; SHASEA, 2003). Dirksen (2001) identified the long-term commitment as one of the most important factors for the success of TG-HDP.

Short-duration projects often fail to measure the extent of adoption/adaptation of the project activities and impact of project activities on the existing farming system, because of their short stay in the target area. Often evaluation carried out within or immediately after completion of the project (for example SUAS, 1990; AusAID, 1999a; AusAID, 2000) does not give the fullest picture, because of slow realisation about the benefit of the technology by farmers, leading to slow uptake. This makes it difficult to determine the impact of the project, unless evaluation of project activities can be carried out after the end of the project (Riley, 1999). So, it is important to study the extent of adoption/adaptation of project activities and the impact of project activities some time after completion of the project, in order to decide if it is worth extrapolating these outcomes to similar areas.

9.7.3 Dissemination and scaling up

The SHASEA Project carried out all farmer-level dissemination and scaling-up activities within Wang Jia. The Project required its entire duration for the direct evaluation of technologies and establishment of development interventions. There was virtually no time left for wider dissemination except within the scientific community. However, the dissemination within the catchment was planned well in the Project proposal (SHASEA, 1997) and that was achieved. But in order to achieve the full impact of Project activities in improving the sustainability of cropping systems and environmental conditions, the technologies need to be adopted across wider areas. Often the outcomes of short-duration projects do not cross the boundaries of experimental stations, identifying on-farm testing and wider dissemination only as areas for future work (SUAS, 1990; SUAS, 1991).

In contrast, some projects, for example TG-HDP and TA-HASD, were able to disseminate the long-term activities and reported the impact of such activities on living standards of target communities, farming systems and environmental condition of the target area (AusAID, 1999b; TG-HDP, 1999; Dirksen, 2001; Dirksen, 2002). Long-term and strong commitments of both funding agency and host government are very important to achieve such accomplishments from any international development assistance (Dirksen, 2002).

The SHASEA Project put considerable effort into disseminating Project outcomes to scientific communities. It produced a considerable number of publications, organised the '*Workshop on Sustainable Highland Agriculture in South-East Asia (SASEA)*' in Yunnan Province, organised a post-Congress tour (*Red Cloud Tour*) for the participants of the '17th World Congress of Soil Science' in Bangkok (14-21 August 2002) and created a website about Project activities (SHASEA, 2003). In recent years, many projects have given emphasis to the documentation of their activities and most produce impressive lists of documents (for example, SUAS, 1991; Turkelboom and van Keer, 1996; TG-HDP, 1999). The funding agencies' requirement for various reports could be one of the driving forces for the production of these documents, but only a small proportion of these are published and readily accessible in the public domain (e.g., refereed journals). With the development of the internet and world-wide-web, many projects/organisations have started to put their publications on websites, which makes some information searchable and more accessible.

9.7.4 Overall success and failure

There is a general tendency to consider the completion of project activities as the full achievement of project objectives, demonstrating project 'success'. Completion of activities is certainly an achievement of an immediate objective, however, this should not be considered as the ultimate success of the project if that fails to make sufficient, lasting improvements for target beneficiaries (Pretty, 2002). Various authors and organisations have defined the success of projects in different ways. Hudson (1991) defined success as the extent to which a project achieved its objectives. He used this definition while evaluating 40 soil conservation projects implemented in Africa. However, when sustainable improvement of farming systems is considered, merely the accomplishment of project activities may not be sufficient for a project to be judged successful. The technical superiority of any technology alone cannot make any positive contribution to the system, unless it is widely used by the farmers and technical superiority is not the only factor that farmers consider for uptake and adoption.

Edwards and Farrington (1993) considered level of uptake of project outputs by users to be the main criterion for judging project success. However, they realized that level of uptake depends on the way the projects are managed throughout the project cycle. So they considered different stages of the project cycle, including relevant issues beyond the main project cycle, to determine the success of a project.

The criteria for judging overall success and failure of project can be different and debatable. In addition, projects implemented to improve agricultural sustainability are generally holistic, multidisciplinary and multi-faceted, which pose greater complexity in evaluating their overall success. Moreover, '*success for whom?*' is an important question where different actors are likely to have different perspectives of success, for example farmers are likely to choose the indicators of immediate success at household level while donors may expect impact over the longer period and may be more concerned on the impact over a larger domain (McDonald and Brown, 1999). These authors have suggested a wide range of criteria (for example, level of uptake, farmers' involvement in all stages of project, post project continuation of uptake, effect on income and food security, downstream effects, effect on land security and other policy adjustment) as possible measures of success.

Often the achievements of different activities of the project are discussed separately rather than in a rating of their overall success (for example, SUAS, 1990). Short duration projects have been found to report the achievement in small activities that can be completed relatively quickly, for example, establishing infrastructures, completing field crops research, providing training, or publishing reports (SUAS, 1991; SHASEA, 2003).

Superficial and more detailed studies both have their own advantages and limitations. Superficial studies provide inadequate details about the effectiveness of the project, while more detailed studies are expensive and require more time and human resources. A more practical method to evaluate a project's success would be to measure the current uptake and study the perceptions of users for the future use of the project technologies. In addition, institutionalisation of research outputs by the extension services for wider dissemination may be an important indicator of project success.

9.8 Achievement of the objectives and overall conclusions of this study

Eight of the original objectives detailed on section 1 (objectives # 1, 3, 4, 5, 6, 8, 9 and 10) have been achieved or substantially achieved, while progress with two (objectives # 2 and 7) has been less satisfactory. The under-achievement of some of the objectives was due to various reasons, such as unavailability of secondary information, unpredictable weather conditions or a temporary delay in study due to a travel ban following a SARS (Severe Acute Respiratory Syndrome) epidemic in China. The degree of achievement for each of the objectives is discussed below.

Objective 1: **To identify current themes and practices relating to agricultural sustainability, with particular reference to the development and implementation of cropping technologies designed to improve sustainability, by a review of the relevant literature.**

This objective has been achieved. The main conclusions of the review are summarised in Chapter 2.4. Earlier development projects had focussed on increasing production, but in the last 30 years much more emphasis has been placed on increasing sustainability. The themes and practices sustainable in one area and one point of time were not always sustainable in other areas and time. This means there is no one blueprint for sustainable systems, which can be effective for all areas through time. There are still different approaches to, and definitions of, sustainability and more evaluation needs to be done on sustainability indicators. There is a considerable literature published on technologies to improve sustainability, but the extent to which these measures have been adopted at a local level as part of routine cropping practices remains a critical issue.

Objective 2: **To identify factors that may have contributed to the effectiveness and degrees of success / failure by reviewing specific projects and programmes implemented in South East Asia, which include a component of research and development on cropping technologies.**

Relatively little progress has been achieved on this objective due to the limited availability of project information, particularly about project processes and those parts of the projects that were less successful. Project Completion Reports including any critical analyses were often held by project sponsors and not generally available. The main conclusions of the review are summarised in Chapter 2.4. Problems of the sustainability of agricultural systems in marginal areas, particularly sloping uplands, have gained more attention from national governments and international aid agencies in recent years. A number of bilateral programmes/projects have been working on the sustainability of agricultural systems; however they vary greatly in scale of operation (project area, duration and funding), focus area and working approach. Project duration has been found to be one of the important factors for project success. Longer duration projects were more successful in addressing more holistic issues than short duration projects. But there is a general lack of critical information on the effectiveness of agricultural development projects in the public domain.

Objective 3: **To give a description of the socio-economic background of Kelang Village, to establish in part the context for the present study, including an assessment of its suitability as the location for the experimental site.**

This objective has been achieved. The main information about the Wang Jia catchment and Kelang village is summarised in Chapter 3.8. Kelang appeared to be a typical rural village of Yunnan, but it had better development structures and economic opportunities than other villages in the region. In particular, access to off-farm employment was high and this may impose limitations in extrapolating the results to other villages more dependent on agriculture. The degree of adaptation and adoption of some of the improved practices might have been higher if the dependence on agriculture had been greater. Aspects of the socio-economic situation in Kelang do not appear to have received sufficient consideration at the time of site selection.

Objective 4: **To produce a description of the rationale, methodologies and outcomes of the SHASEA Project, summarising the conclusions drawn and attempting an evaluation of the short-term results of the project; this will also provide further contextualisation for the present study.**

This objective has been achieved. The main conclusions of the SHASEA Project are summarised in Chapter 4.9. The Project was able to carry out a comprehensive scientific evaluation, with effective initial dissemination within the catchment. The technical outputs of the Project have been described as successful in achieving project goals. However, the evidence on farmers' adoption of Project technologies by the end of the project was limited, which was probably related to the low level of effective farmer participation that was attempted and achieved from the outset. Achieving greater participation from the planning stage could have increased ownership of the project outcomes.

Objective 5: **To determine the perceptions of local farmers (family households) on the effectiveness of the technologies introduced by the Project and the likelihood of their future adaptation and adoption, using both household surveys and participatory rural appraisal (PRA).**

This objective has been achieved. The conclusions from the household survey are summarised in Chapter 5.5 and the conclusions from PRA workshops are presented in Chapter 6.5. Overall, farmers had different perceptions about the range of practices introduced into the catchment. Contour cultivation technology was highly preferred and was likely to be adopted, while straw mulching and intercropping were considered inappropriate and were unlikely to be adopted. Other agricultural practices would only be adopted if the financial returns were favourable, such as the use of polythene mulch. Longer-term measures, such as tree planting schemes, were regarded favourably, but adoption would still depend on economic returns and related issues such as land security. An irrigation scheme was suggested by the farmers, but after installation it was not used extensively for the staple crops in the catchment. The benefits of an innovative, integrated cropping system, INCOPLAST, were not fully appreciated by the farmers. Training and dissemination activities were conducted primarily within the Project area and focused on research activities. Wider dissemination of project technologies to other local farming communities was not attempted. Farmers' willingness to adopt effective agricultural practices in the future was influenced by the availability of information mainly through training and extension. Therefore there is need for further dissemination work in order to achieve wider adaptation/adoption of the SHASEA Project technologies.

***Objective 6:* To determine the views of available local stakeholders on the technologies introduced by the Project, their initial impact, dissemination, possible extension, adaptation and adoption.**

This objective has been achieved, but only for a limited selection of available stakeholders. The main conclusions are presented in Chapter 7.6. It was recognised by the stakeholders that the preference of farmers for particular agricultural technologies was based on ease of operation, economic profitability, availability and suitability in existing farming systems. The Project activities were well appreciated for improving environmental conditions in the catchment, particularly for flood control, which substantially reduced the risk of destruction to village houses. The need for wider dissemination of Project outcomes was mentioned by most of the stakeholders. There was inadequate communication between Project researchers and local extension officers at the Township level and with policy makers at Provincial level. Wider dissemination of Project technologies through Government extension networks and policy decisions would have been easier if the Project had established early and regular communication with such decision-making bodies.

Objective 7: **To complete an additional analysis, of the biological, environmental and economic impacts of the Project technologies, through further monitoring by field survey, direct observation and economic analysis.**

This objective has only been partially achieved. The main conclusions of the direct observation of the farmer-managed experimental plots, survey of the tree planting activity, observations on the soil and water losses from the catchment and the economic analysis are presented in sections 8.1.5, 8.2.5, 8.3.5 and 8.4.4, respectively.

The extent of the farmers' adoption/adaptation of Project technologies during the Project period was variable and directly influenced by Project efforts (dissemination, training, subsidy and compensation). In the future, the use of these technologies by farmers is likely to change, once farmers are given complete freedom to determine their cropping strategy. Change in the farmers' practice, before and after Project intervention, could not be studied in detail because of limited baseline information.

The DES could not be conducted as planned because of unpredictable weather conditions and delays as a result of a travel ban to the study site due to the SARS problem in China. From limited surveys carried out, contour cultivation has the potential to reduce soil and water erosion in sloping uplands. Most erosion features were studied on uncultivated land, as they are frequently destroyed on cultivated land during farming operations.

Economic analysis revealed that mulching and intercropping technologies introduced by the SHASEA Project were economically more profitable compared to the farmers' practice. The potential benefits from sweet chestnut and prickly ash trees were much greater than for arable crops in the long-term. However, the income from trees was less than that from arable crops during the early growth period of the trees. The first six years would be difficult for the poorer farmers, so any tree-planting programme must be accompanied by either a subsidy or alternative income-generating options for the early years.

Objective 8: **To achieve a synthesis of the outcomes from the approaches identified above to obtain a more holistic view of the impact of the Project, its short-term outcomes and potential longer-term effectiveness in relation to future adaptation and adoption, leading to the final conclusions of the present study.**

This objective has been achieved. The synthesis of the outcomes for this study, considering the short-term results of Project activities with further analysis of the potential longer-term effectiveness is presented in previous sections of this Chapter. The final conclusions are:

- The SHASEA Project was successful in achieving its scientific and technical objectives. Some of the technologies introduced by the SHASEA Project were effective in improving crop productivity and reducing soil and water losses. But at the end of the three-year project, it was not clear what the long-term benefits would be.

- Other short duration projects have produced similar outcomes. By contrast, longer duration projects are able, not only to commit more time to dissemination but also follow through to the processes of adoption and adaptation and possibly achieve greater success in the long term. Alternatively local systems must be put in place to continue the developments introduced by the project after the main funded period comes to an end.

- This study has investigated the initial uptake of Project technologies by the farming communities in Wang Jia catchment, their perceptions about the usefulness of the technologies and their intentions for future adoption. The study revealed that despite the technical and scientific success of the Project, long-term adoption of many of the practices introduced into the catchment will be low, unless considerable incentives are used or much more effective dissemination techniques employed.

- It is considered that the outcomes would have improved considerably if participatory approaches had been used from the outset, to engage farmers more fully with the project, to ensure that the practices introduced were as appropriate as possible, to achieve greater ownership of the objectives and outcomes, leading to higher adoption rates.

- More emphasis should have been given to the dissemination of the outcomes at farmer level outside the study catchment and there should have been more involvement with the regional policy makers and extension officials throughout the programme.

- Longer-term improvements in sustainability at the catchment level have not yet been demonstrated. Continued use of contour cultivation and extension of the tree planting schemes may lead to significant improvements in sustainability in the future.

Objective 9: **To identify good practices for the development, implementation and dissemination of similar projects in the future.**

This objective has been achieved. The following points are presented below as recommendations of good practice for planning/designing, implementing and disseminating research and development projects.

- Work in line with the research and development agenda of local stakeholders. This will help to ensure that project efforts will be effective in alleviating local problems and achieving local needs.
- Work with the existing local research and development networks. This is helpful in integrating outcomes of the project with existing local research and development systems and is important to ensure wider dissemination of research and post-project utilisation of project outputs.
- Ensure adequate sharing of project goals with all partners and stakeholders, so that all partners and stakeholders are aware of the mission of the project and their roles, responsibilities and contributions necessary to achieve project objectives; local ownership of the project is very important.
- Avoid ambitious planning of project activities that cannot be completed within the stipulated time and resources. If any activities are expected to remain incomplete by the end of the project or as a result of the limited availability of resources, then continuation strategies for the completion of such activities should be in place. The continuation strategy may include identification of activities to be completed, institutions to be responsible and sources and amount of resources.
- Record baseline information before the start of the project interventions, in order to study the progress and effectiveness of the project in the areas of intervention.
- Use farmer participatory approaches in all stages of research and development, i.e. planning, implementation, evaluation and dissemination (scaling-up). Farmers were found to be capable of evaluating the environmental condition of a catchment, identifying suitable indicators and using them during evaluation. Effective dissemination can be

achieved by involving farmers in the scaling-up process, as '*other farmers'* were one of the important sources of information for farmers.

- Ideally, consider technology with the following characteristics: appropriate balance between quick returns and longer-term benefits; inputs associated with the technology should be available locally, in time and at a reasonable price; the technology should not demand extra labour and costs without the extra returns being clearly identified; new or modified technologies should be capable of being accommodated within the existing system. Where these ideal conditions are not met, it should be recognised that additional incentives may be required to improve adoption.
- Provide adequate training to increase farmers' awareness about the longer-term benefits of conservation strategies and thereby achieve more effective dissemination and adoption.
- Provide subsidy or compensation to farmers where additional income from the technology is delayed or remains less than current income for some time. It is necessary to discuss fully the objective and duration of such subsidy or compensation programme with farmers.
- Involve policy makers at an early stage in the project if policy support is likely to be required to achieve all the project objectives. This is particularly important when attempting to improve sustainability which may not be associated with tangible short-term benefits.
- Discuss and agree future (post-project) courses of action with local partners. Ensure that the funding agency's conditions are fully understood and accepted by all partners. Where possible, sources of on-going local support should be identified while the main project is running.

Objective 10: **To identify the limitations of the present study and outline areas for future study.**

This objective has been achieved. The limitations of this study are presented below.

- *Work pace:* The author enjoyed the unbeatable hospitality of Chinese colleagues and farmers during the field studies in China; very good cooperation was received from everybody who was approached. However, the pace of the fieldwork was controlled by the availability of interpreters and village officials who guided us to farmers' houses. This inevitably slowed down the rate of progress and limited the scope of work.

- *Chinese tradition:* Farmers tended to give only positive responses even after repeated requests for critical comments about the Project. Chinese people feel shame about describing any mistakes or shortcomings, particularly to foreigners. Farmers' perceptions about the weaknesses of the Project might have been documented more thoroughly if this aspect had been carried out by a Chinese (local) researcher.

- *Translation:* The questionnaires were developed in English, which needed to be translated into Chinese in order to make it possible for Chinese enumerators to pose the questions to farmers. It was planned to follow a proper translation procedure (i.e.: i. one person to translate from English to Chinese; ii. another person to translate from Chinese back to English; iii. to compare this translated English version of the questionnaire with the original one to check that it is correctly translated). However, this could not be done due to the unavailability of translators at the time of survey. Similarly, farmers' responses might have been distorted during the translation. Farmers have their own way of expressing their experience and knowledge about the scientific phenomenon of farming. Farmers use their indigenous knowledge base, perpetuated through the generations, and their personal experience to express their views, which are often very interesting and provide information about the interaction between the local situation and scientific theory. Translating such expressions in a foreign language is difficult, requiring very good command of both of the languages. The translators available had limited professional experience and this made it difficult to translate such farmers' responses in the way they had been expressed. As a result, farmers' responses often read like a researcher's observation.

- *Baseline information:* Baseline data would have provided a more reliable basis for measuring changes. It is essential for comparing situations before and after Project intervention. The lack of extensive local baseline data limited the interpretations that could be drawn.

- *Delays to some measurements:* The field study in 2003 was delayed until July because of the ban on travel due to the SARS Epidemic in the South Asia region. In 2003, the catchment received a significant proportion of its rainfall before July and after that it remained fairly dry. This posed difficulties in studying the erosion features due to limited rainfall and runoff during the observation period.

The following points are presented below as suggestions for further investigation.

- Generation of post-project baseline information would help in monitoring progress in the adoption and impact of project technologies for the future.

- Under researcher-managed plots, the integrated INCOPLAST technology proved to be successful in increasing crop productivity as well as improving soil and water conservation. However, very few farmers adopted the whole package of this technology, while the majority of farmers adopted some of the components of the system. It is necessary to investigate further the factors, both technical and socio-economic, which have limited the adoption of this effective integrated cropping system.

- Low availability was one of the major reasons for poor initial uptake of straw mulch technology. Investigation of ways to increase straw production is necessary to achieve better adoption of this technology by farmers.

- This study presents information about the monitoring of impacts and the early adoption of the Project technologies by the farmers. Wider adoption of technologies at the time of this study was limited and a much longer monitoring period would be required to draw definitive conclusions on long-term adoption and the wider socio-economic impact of the development programme.

- Farmers were reluctant to use the intercropping system recommended by the Project. Lack of suitable varieties, particularly of the companion crop, was one of the important reasons. Further work is required to develop more appropriate systems for this area.

- Effects of white pollution (pollution due to polythene) on the cropping environment should be studied and ways for reducing any adverse effects investigated.

- Government subsidy on polythene may be one of the reasons for its widespread use for mulching; however, this subsidy may not continue indefinitely. Further studies should investigate how farmers will respond when the subsidy on polythene is lifted by the Government.

- Farmers perceived that use of contour cultivation on sloping lands increased lodging and weed problems, although published information was not available to verify these perceptions. A further study should investigate the relationships between contour cultivation, weed problems and tendency to lodge.

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Annex 2.1: List of projects implemented in South Asia during 1970-2001.

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
1	Integrated technical and socio-economic approaches for reclaiming degraded forestland (REDFOL), China.	3 yrs (1995-1998) IDRC + CIFOR + China Not available	• Sustainable production system • Tri-D (Diagnosis, Design, Delivery) approach • PRA, participatory data collection, analysis and diagnosis of the problems • Marginal (degraded land) ecosystem	• Relevance-A • Limited information at hand
2	Watershed project, PARDYP (People and Resources Dynamics Project).	7 yrs (2 phases: 1996-1998; 1999-2003) IDRC + SDC + ICIMOD PARDYP Project International centre for Integrated Mountain Development (ICIMOD) PO Box 3226 Kathmandu, Nepal.	• Natural resources management • Participatory action research, dissemination, and training • Mountain farming system	• Relevance-C (Incomplete) • Phase-I report at hand
3	Vietnam-Finland forestry sector co-operation programme, Bac Thai province.	3 yrs (1996-98) Finland + Vietnam venture FTP International Ltd Tel. +358 5 2208 468 Fax. +358 9 7701 3499 e-mail: juha.kiuru@ftpinter.fi	• Income generation • Social forestry, Farm forestry practices, alternative to shifting cultivation • Participatory approaches • Mountainous region, ethnic minority	• Relevance-A • Limited information
4	The Vietnam-Finland forestry sector co-operation programme, Bac Kan province.	7 yrs (2 phases: 1996-98; 1999-2003) Finland + Vietnam C/o Secretariat of the International Support Group, Ministry of Agriculture and Rural Development 1A Nguyen Cong Tru, Hanoi	• Income generation through sustainable forest management and farm forestry practices, alternative to shifting cultivation • PRA, community development, capacity building, dissemination, and M&E. • Mountainous region, ethnic minority	• Relevance-C (Incomplete)

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
5	Farmer participatory research and technology transfer on the use and management of sloping lands in Vietnam's (VIETCANSOL Project).	6 yrs (2 phases: 1995-97; 1998-01) CIDA through AIC (Canada) Contact: Tom Beach idap@aic.ca	• Soil-water conservation, cash crops, environment and economic sustainability • Participatory, GIS • Mountainous region of North Vietnam • Very good impact reported, but direct beneficiaries are only 150 households.	• Relevance-A** • Final report (synopsis) received, other reports requested.
6	Community-Based Research and Extension in the Rehabilitation of Degraded Mountain Ecosystem of the Hindu Kush-Himalayan Region.	3 yrs: ?? (completed) IDRC+SDC+ICIMOD Contact: Pei Shengji pei@icimod.org.np, Project Coordinator	• Participatory, socio-economic processes • Rehabilitation, degraded areas • Hindu Kush himalayan region	• Relevance-A • One proceedings at hand • Information not available in internet, ICIMOD – to contact.
7	EROCHINUT: An Interdisciplinary Approach to Reducing Nutrient Losses and Enhancing Watershed Management in China.	3 yrs (1998- 2001) IIED International Institute for Environment and Development (IIED) 3 Endsleigh Street London WC1H 0DD, UK	• Alternative land and water management system, Soil erosion and nutrient modelling • Capacity building • Participatory research and M&E techniques • Hilly purple area, Sichuan, China	• Relevance-NR
8	Appropriate Technologies for Soil Conserving Farming Systems.	3 yrs (1998-2001) ADB + ICIMOD + National partner International centre for Integrated Mountain Development (ICIMOD) PO Box 3226 Kathmandu, Nepal. Attn: Tang Ya tangya@icimod.org.np	• SALT technology, soil erosion, soil fertility, compost making, bio-engineering, water harvesting • On-farm research, demonstration and extension, training • Good adoption reported	• Relevance-A

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
9	Soil Fertility Conservation Project 1989-1995.	7 yrs (3 phases: 1989-1992, 1993-1995, 1995-1998) Catholic University, Luven + Mae Jo University, Thailand Department of Soils and Fertilizers Mae Jo University Mae Jo – San Sai Chiang Mai 50290, Thailand	• Cropping system, on-farm research, soil fertility conservation and crop management • Soil erosion and soil-borne pests • Changes in land use and cultivation practices • Highland farming system	• Relevance-A* • We have Research highlights and one article- we need PCR.
10	Soil Conservation and Sustainable Agriculture on the Loess Plateau: Challenges and Prospects	20 yrs China Academy of Sciences, Institute of soil and water conservation, Yangling 712100, Shaanxi, Peoples Republic of China	• Soil conservation at watershed-scale, sustainable agriculture, human activity • Integrated programme including grain production, fruit, livestock, forestry • Very good success reported, e.g. farmers' income increased by 8 folds and erosion decreased by >70%	• Reference-A • We have one article published in Ambio.
11	Improving the agricultural productivity from upland sandy soils in NorthEast Thailand through soil organic matter management.	4 yrs (1990-1994) EC + Thailand Not available	• Not available	• Relevance-B
12	Sustainable environmental management strategy in South China – towards 2000 and beyond – a case study in Shenzhen.	2.5 yrs (1997-1999) EC + China Not available	• Sustainable environmental management, water resources management • Socio-economic and environmental problems • Decision support system (DSS), Remote sensing, GIS, Survey	• Relevance-NR
13	Institutions for sustainable development in ecologically sensitive areas in China.	2.25 yrs (1993-1995) EC + China Not available	• Sustainable agriculture, ecologically sensitive areas, analysis of existing environmental policy, strategies for future • Institutional and socio-economic analysis	• Relevance-NR

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
14	Improved water and soil management for sustainable agriculture in the Huang-Huai-Hai rivers plain (North China).	4.5 yrs (1994-1998) EC + China Not available	• Water resource and management (distribution system) • Model water fluxes, irrigation • Soil management technology development • Socio-economic survey	• Relevance-B
15	An interdisciplinary approach to reduce water, soil and nutrient losses by erosion in the agricultural Hilly Purple area, Sichuan Province, China, by combined use of participatory and modelling techniques.	3 yrs (1999-2001) EC + China Not available	• Not available	• Relevance-NR
16	A participatory approach for soil water conservation planning, integrating soil erosion modelling and land evaluation, to improve the sustainability of land use on the loaess plateau in Northern China.	- EC + China Not available	• Develop alternative land use and conservation strategies • Participatory planning method, integrates soil erosion model+ land evaluation techniques. • Land Inventory, field monitoring, validation of erosion model, GIS, land evaluation, P-planning,	• Relevance-C
17	Methodologies for assessing sustainable agricultural systems in the Hindu-Kush Himalayan region.	3 yrs (1998-2001) ADB + ICIMOD + National partner International centre for Integrated Mountain Development (ICIMOD) PO Box 3226 Kathmandu, Nepal. Contact: Nyima Tashi/Argen Rotmans, mfs@icimod.org.np	• Mountain agricultural systems database • Tool for characterisation, delineation and land use analysis • Sustainable development, regional context, localised planning	• Relevance-NR

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
18	The EROCHINA soil erosion project in Loess plateau of China.	3 yrs (1997- 2000) EU Funding - Netherlands, Sweden and Chinese venture (6 collaborators) Alterra, Land use and soil processes team, PO Box 47, 6700 AA Wageningen, The Netherlands www.Alterra.wageningen-ur.nl/erochina	• Alternative land use and soil and water conservation strategies • Soil erosion, sustainability, alternative land use • Participatory planning, Integrated approaches, soil erosion modelling	• Relevance-A* • One proceedings at hand; we need PCR if selected.
19	8 years of economical and ecological experience soil-conserving land use.	8 years Munich Research Alliance on Agroecosystems (FAM) -	• FAM research alliance • Organic and integrated farming, site-specific soil conservation system, cropping practices, soil properties • Economic return • Limited information about project description.	• Relevance-B • Reference document
20	Comparative evaluation of cultural practices to conserve soil and water on the highland slopping Northern Thailand.	4 yrs (1999-2002) EU funding: University Wolverhampton + Yunnan Agricultural University +Chiang Mai University collaboration Dept of Soil Science, Faculty of Agriculture, Chian Mai University Chiang Mai, Thailand	• Contour cultivation, alley cropping, mulch • Productivity, soil and water conservation, soil fertility • Sloping area	• Relevance-C (Incomplete)
21	SHASHE project.	4 yrs (1999-2002) EU funding: 7 European and Asian partners co-ordinated by University Wolverhampton School of Applied Sciences, University of Wolverhampton, Wulfruna Street, Wolverhampton WV1 1SB, UK.	• Alternative cropping practices, Crop productivity, sustainability, soil erosion, characterisation of catchment environment, socio-economic impacts • Contour cultivation, ridge planting, mulching, inter-cropping, irrigation, tree planting • Sloping highland, red soils • Multidisciplinary, research, demonstration	• Relevance-B (Probably some aspects can be used)
22	Integrated farming systems: an important approach towards sustainable agriculture in China.	- - -	• Integrated farming systems (IFS), sustainable agriculture	• Relevance-C • Reference document •

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
23	UNEP initiatives on success stories in land degradation-desertification control: Summaries of 'saving the dry lands' award-winning-projects.	20 yrs (Duration not known) UNEP - -	• Summaries of 18 successful land degradation/ desertification control project • Forestry, agroforestry, erosion soil and water conservation, land use, community development, pollution and degradation, participation and self-help	• Relevance-B • Reference document • Information not received
24	Chinese-Swedish soil conservation coordination project	4 yrs (1987-90) Swedish University + Shaanxi Academy of Agricultural Sciences International Rural Development Centre, Swedish University of Agriculture Sciences	• Soil conservation and improvement, forest, natural resources • Biological soil improvement and conservation, fruit and forage production • Institutional and personal capacity building, research and training	• Relevance-A*** • We have 4 reports AR '87 & '88, PCR, and Project Evaluation Report.
25	Alleviating poverty: twenty years of European community support in Asia.	20 yrs EU Support Commission of the European communities, Brussels, Belgium	• Various project • Poverty alleviation, food security, social development, environment, gender, relief and rehabilitation • Policies, programmes and assistance strategy of EC	• Relevance-B • Reference document
26	Sharing knowledge for better land husbandry in the uplands of Northern Thailand: a concept for on-farm research.	?? yrs (Initiated in 1995) Thailand + IBSRAM IBSRAM PO Box 9-109 Jatujak, Bangkok 10900, Thailand	• Soil conservation, land husbandry, hedgerows, grass strips, dissemination • Farmer-centred decision making process adopted • Test bottom-up approach	• Relevance-B • Good but only one article at hand, info requested to IBSRAM.
27	Evaluation and improvement of farming systems combining agriculture, animal husbandry and fisheries in Mekong delta	5 yrs (1994-1999) Japan (JIRCAS) + Vietnam Japan International Research Center for Agriculture Sciences (JIRCAS), Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Ibaraki 305-0035, Japan.	• Farming system, food security, rice, water quality, pollution and insecticidal hazards • Socio-economic survey, agronomic research, fertilizer trials, IPM,	• Relevance-B • Reference document • We have one brief article.

S No	Project/publication title	**Project duration, Collaborating institutions, Contact address**	Main features	Remarks
28	Evaluating sustainability of intensive farming system	- China -	• Sustainable agriculture, food security, poverty alleviation, farming system, rural economy, rural employment, soil conservation, social benefits • Indicators and models • Case study	• Relevance-B • Reference document
29	"New" seed in "old" China: Impact of CIMMYT collaborative programme on maize breeding in South-Western China	30 yrs (1970-2000) CIMMYT + China Wageningen Agricultural University, Wageningen, Netherlands.	• Collaborative programme, food security, maize breeding, Productivity, • Assessment, adoption, diffusion • Regional variation, user differentiation	• Relevance-B • Reference document
30	Poverty reduction and food security in China. The Sino-German food security programme Shandong.	10 yrs (initiated in 1988) China + GTZ (Germany) Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH Beijing, China	• Drinking water, crop productivity and diversity, soil fertility • Community participation, rural poverty, equity, food security, equity • Very good success reported.	• Relevance-A • Reference document • We have one short article
31	Participatory forest management: implications for policy and human resources, development in the Hindu Kush-Himalayas	Initiated in 1993 ICIMOD + Nepal, China, India, Myanmar, Bhutan, Bangladesh, Pakistan International centre for Integrated Mountain Development (ICIMOD) PO Box 3226 Kathmandu, Nepal.	• Forest and natural resources, sustainable management, policy implications, community participation, benefit sharing, tenure arrangement, community rights, equity, gender	• Relevance-B • Reference document • Two ICIMOD Proceedings at hand.
32	Approaches to on-farm research in Asia: Summary proceedimgs of the Regional Workshop on On-farm Adaptive Research, Feb 1993, Ho Chi Minh City, Vietnam.	yrs (initiated in 1988) ICRISAT + Indonesia, Nepal, Sri Lanka, Vietnam International Crops Research Institute for the Semi-Arid Tropics Patanchery, A.P. 502 324, India	• Participatory approaches, adaptive on-farm research, Farming System Research, production technologies, capacity building, NARSs, grain legumes	• Relevance-B • One proceedings received Requested to ICRISAT for detail info.

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
33	Upland cropping systems in the highlands of Northern Vietnam: a minor field study.	- Vietnam + SUAS (Sweden) Swedish University of Agriculture Sciences (SUAS) Uppsala, Sweden	• Agro-forestry, soil conservation, cropping systems, hedgerows, inter-cropping, sloping land, shifting cultivation • Economic evaluation, farmers' perception	• Relevance-C • Reference document
34	Impact of rice research and technology dissemination in Indonesia.	- - IRRI, Manila, Philippines	• Rice research and technology dissemination, adoption, food security	• Relevance-C • Reference document
35	Proceedings workshop Wageningen-China	- - Research Institute for Agrobiology and Soil Fertility. AB-DLO, P.O. Box 14, 6700 AA Wageningen, Netherlands.	• Soil conservation, resource management, food security, world food market, political decision, socio-economic attainability.	• Relevance-B • Reference document
36	The slopping lands network and the opportunity for technology transfer.	9 years (3 Phases: 1988-1991; 1992-1994; 1995-97) SDC and ASIALAND (IBSRAM) + China, Indonesia., Lao Malaysia, Philippines, Thailand, Vietnam, IBSRAM PO Box 9-109 Jatujak, Bangkok 10900, Thailand	• Soil conservation technologies (hedgerows, alley cropping, agro-forestry, chemical fertilisers, mulching), appropriate technology, farmers' practice, technology transfer. • Soil loss, crop yield, economic benefit	• Refer P#16. • Relevance-A* • Reference document • Received considerable information from IBSRAM.
37	International symposium on alternatives to slash-and-burn agriculture, Kunming, China.	- ICRAF + China Institute of soil science, Academia Sinica, PO Box 821, Nanjing, China.	• Slash-and-burn agriculture, indigenous knowledge, history and succession, practice and analysis, • Alternatives to slash-and-burn agriculture through agro-forestry, natural resource protection	• Relevance-B • Reference document • Oxford Library • ICRAF
38	Special issue: Ecosystem research and development in China. By E. Kessler.	Ambio. 1999. 28: 8, 635-686. ***Search CERN web site***	• This special issue contains 9 papers on biodiversity, ecosystem protection, land use, food production, soil conservation, and hydrodynamics, resulted from a joint seminar by Swedish Academy of Sciences and Chinese Ecosystem Research Network (CERN).	• Relevance-C • Reference document • Journal

S No	Project/publication title	**Project duration, Collaborating institutions, Contact address**	Main features	Remarks
39	Sustainable and effective management systems for community forestry	- - Regional Community Forestry Training Center for Asia-Pacific (RECOFTC). Bangkok, Thailand	• Community forestry management, sustainability, local initiatives, women and children, Asian experiences.	• Relevance-B • Reference document • Workshop proceedings
40	Integrating biophysical and socio-economic aspects of soil conservation on the Loess plateau, China.	- UEA (UK) + China School of Developmental Studies, university of East Anglia (UEA), Norwich, NR4 7TJ, UK.	• Soil erosion and conservation, biophysical efficiency, productivity, sustainability, socio-economic acceptability, alternative cropping system • Bench terraces, grass strips, ridge tillage • Decision making framework, cost of erosion, productive life of soil, organic matter,	• Relevance- B Reference document • 3 Journal articles at hand
41	Initiating Participatory technology Development (PTD). Experiences with two different procedures in Northern Vietnam.	- Helvetas + Vietnam -	• Participatory Technology Development (PTD), Training, • Two PTD-introduction methods applied in two Helvetas Projects: input by trainers Vs interaction between staff and farmer.	• Relevance-C • Reference document • Journal article
42	A Case study of ecological restoration at the Xiaoyi Bauxite Mine, Shanxi Province, China.	- - *Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China*	• Theories and methods for ecological restoration of mines • Engineering and biological reclamation • Stripping, mining, peeled off, and rehabilitation • Advanced farming techniques and biotechnology	• Relevance-C • Reference document
43	Natural resources and environmental management (NREM)	7 yrs (1992-1999) CIDA + Thailand No contact address	• Focus on planning, NRM, and capacity building • Natural resources and environment, integrated approach, transfer of technology	• Relevance-B
44	Participatory natural resource management in the Tonle Sap region	6 yrs (1995-2000) FAO + Belgium + Cambodia Participatory natural resource management in the Tonle Sap region, FAO/DAFF Siem Reap, Cambodia fao-sr@rep.forum.org.kh	• Sustainable management, NRM, agricultural productivity, soil improvement, food security, income generation • community forestry, agro-forestry, horticulture, micro-irrigation, aquaculture, wood energy, rural credit	• Relevance-A

S No	Project/publication title	**Project duration, Collaborating institutions, Contact address**	Main features	Remarks
45	Development and training in appropriate technology for tree farmers	4 yrs (1991-1994) Finland + Philippines FTP International Ltd Tel: +358 9 7701 3317 Fax: +358 9 7701 3499 mark.seymour@ftpinter.fi	• Appropriate technology, sustainable rural development, non-governmental forestry, women participation, forest tree harvesting • Problem identification, training, technology development	• Relevance-B
46	Social forestry development project (SFDP) Son La	12 yrs (4 phases; 1993-2004) SNV (Netherlands) + Vietnam No contact address	• Sustainable management, NRM, livelihood, watershed conservation, community forestry • Participatory approaches, village based methodology, capacity building, participatory extension	• Relevance-B (Incomplete but long term project) • About 50 reports in internet.
47	Sustainable utilization of non-timber forest products	3.5 yrs (1998-2001) SNV (Netherlands) + IUCN + Vietnam No contact address	• Sustainable use of NTFPs, sustainable harvesting, cultivation of NTFPs, integrated research,	• Relevance-NR
48	Philippines-Australia Agricultural Technology Education Project (AGRITECH)	12 yrs (1988-2000) AUSAID (Australia) + Philippines AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Agricultural education for Agricultural development • Provincial and regional levels • Rural communities	• Relevance-B • We have Project evaluation report.
49	Pilot Provincial Agricultural Extension Project (PPAEP)	9 yrs (1987-1996) AUSAID (Australia) + Philippines AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Extension services, effectiveness, sustainability, improve productivity and income, rural households	• Relevance-A* • We have Project evaluation report. We need PCR.
50	Forage for smallholders project (FSP)	6 yrs (1994-2000) AUSAID (Australia) + Philippines AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Increase agricultural productivity and soil sustainability, rural households, small holder farm, upland system • Forage, agro-forestry	• Relevance-A* • We have Project evaluation report. We need PCR .

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
51	Rice Production in Cambodia. Cambodia-IRRI-Australia Project (CIAP).	9+ years (1987-1996, Phase-IV initiated in 1997) Cambodia + IRRI + Australia Cambodia-IRRI-Australia Project PO Box 01, Phnom Penh, Cambodia	• Technologies for rice based farming systems • Research (breeding, agronomic, social, economic), training, institutional development • Rice based ecosystem, food security, sustainability	• Relevance-B* • We have Project evaluation report. We need PCR.
52	Highland agriculture and social development (HASD) project	5+ yrs (Phase II: 1988-1993) AUSAID (Australia) + Thailand AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Farming system, highland, increase crop productivity, reduce environment degradation, participatory planning, capacity building, women development • Crops, vegetable, grass strips, health, education, community activity	• Relevance-A* • We have Project evaluation report. We need PCR.
53	Thai Australia agricultural extension project (TAAEP)	3.5 yrs (1991-1995) AUSAID (Australia) + Thailand AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Extension methods, farmer participation in extension and planning, bottom-up planning process training, women development, group development, self-sustaining group	• Relevance-B • We have Project evaluation report
54	Ubon Ratchathani land reform area project (ULRAP)	3.5 yrs (1991-1995) AUSAID (Australia) + Thailand AusAID, GPO Box 887, Canberra ACT 2601, Australia	• Environmental degradation, alternative NRM strategy, diversified farming system, sustainable agriculture, local group development, capacity building, training, improve local road and water supply, monitoring and evaluation.	• Relevance-A* • We have Project evaluation report. PCR needed.
55	Hebei watershed management and livestock production project	5 yrs (1995-2000) AUSAID (Australia) + China Xingtai City, Xingtai County, Hebei Province, China	• Watershed, irrigation and livestock development, alternative and sustainable farming method • Village level participatory watershed development plan, cattle industry strategic plan • Support services, extension services, mass media programme, integrated model	• Relevance-C
56	Community-based NRM in the mountainous area of Guizhou province (China)	6 yrs (1995-1998; 1998-2001) IDRC (Canada) + China Guizhou Academy of Agricultural Sciences (GAAS), Jinzhu Zhen, Guiyang 550006, Guizhou Province, China. Email: cirdr_gy@yahoo.com	• NRM, sustainable & equitable economic development, participatory, community empowerment, food security • Focus on reducing drudgery of human life (drinking water project), fruit orchard plantation, forest management, income generation • Good impact reported	• Relevance-A • One brief article at hand

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
57	Natural Resource Management Network (Vietnam)	6 yrs (1994-2000) IDRC (Canada) + CIAT + SDC + Vietnam Le Van An, Deputy Head, Dept of Science and International Relations Hue University of Agriculture and Forestry 24 Phung Hung, Hue City, Vietnam Email: upland@dng.vnn.vn	• Reduce swidden agriculture, limit forest destruction, food security, • Degraded/marginal area • Sustainable NRM, community participation, training and capacity building • Crops, horticulture (home garden), livestock • Very good impact reported	• Relevance-A • One brief article at hand
58	Tarim basin desertification and water management	7 yrs (1994-1998; 1998-2001) IDRC (Canada) + China **Prof. Dai Jian,** Director, Institute of Agricultural Economy and Information, Xinjiang Academy of Agricultural Sciences, Urumqi, Xinjiang, China 830000. email: iaei@xj.cninfo.net **Prof Yu Suhua**, Institute of Techno-Economic and Energy Systems Analysis, Tsinghua, University, Beijing, China 100084. email: suhua@inet.tsinghua.edu.cn	• Water resources management, irrigation policy, improve agricultural and irrigation technologies, alternative technologies, institutional innovation, socio-economic impact • Water pricing, participatory approach, gender differentiated need and impact	• Relevance-B • One brief article at hand
59	Community based upland resource management	8 yrs (1993-1998; 1998-2001) IDRC (Canada) + Vietnam John Graham, IDRC, Canada.	• Alternatives to swidden farmers for food security, income and NRM. • Different approach adopted: PRA training- programme identification- implementation • High yielding varieties, improved pigs, women's union, home garden, training, capacity building.	• Relevance-B • Very limited information at hand
60	Mountain resource management	3 yrs (1992-1995) IDRC (Canada) + University of British Columbia (Canada) + ICIMOD + Nepal International centre for Integrated Mountain Development (ICIMOD) PO Box 3226 Kathmandu, Nepal.	• Built on existing 'Jhiku Khola Project' • Soil erosion, fertility management, sediment budget, sediment trapping, environmental change, land use change, indigenous knowledgebase systems (IKS) • Grazing land cultivated land, nutrient transfer, alternative resource management approaches, GIS • Farmers performed M&E	• Relevance-C • One proceedings received from ICIMOD

S No	Project/publication title	**Project duration, Collaborating institutions, Contact address**	Main features	Remarks
61	Food security in arid uplands	4 yrs (1993-1997) IDRC (Canada) + Indonesia University of Udayana, Indonesia John Graham, IDRC, Canada.	• Document existing knowledge and practice in farming system, socio-economic condition of farm family, resource management system, food security, family welfare	• Relevance-B • Very limited information at hand.
62	Reclaiming degrading land	5 yrs (1995-2001) IDRC (Canada) + China John Graham, IDRC, Canada.	• Management of degraded lands, sustainable use, agroforestry, marginal ecosystem • Integrated and interdisciplinary research approaches	• Relevance-B • Limited info at hand.
63	Poverty reduction and environmental management in remote Greater Mekong Sub-region (GMS) watershed	- (Initiated in 1998) ADB + Greator Mekong Sub Region C.R. Rajendran Senior Project Specialist AWFN, ADB Crajendran@adb.org	• Policy and strategy development to alleviate deforestation and environmental degradation • Food security and sustainable NRM, forest management, watershed • Poverty, education, land tenure, ethnicity, migration	• Relevance-B* • We have Executive Summary of the Final Report.
64	Improvement of the sustainability of cassava-based cropping systems in Asia.	5 yrs (1993-1998) Nippon foundation + CIAT + Thailand, Vietnam, Indonesia, China CIAT Regional Cassava Program in Asia, Dept. of agriculture, Chatuchak, Bangkok 10900, Thailand	• Integrated soil/crop management technologies for cassava based system, soil conservation, soil fertility, erosion • Farmer participatory research, Training-of-Trainers, RRA, adoption, extension	• Relevance-A* • 2 articles at hand, requested to CIAT-Library for detailed information
65	Luang Namtha integrated rural development project, Laos	3 yrs (1998-2000) EC + Laos AHT International GmbH Huyssenalle 66-68 D-45128 Essen, Germany Or, (PO Box 100132, D-45001 Essen) email: aht@aht-inter.com	• Tribal and subsistence community, • Livelihood, food security, health, education, water supply. • Integrated upland cropping, cash crop, livestock, fish production • Support to extension services	• Relevance-B • Very limited information at hand.

S No	Project/publication title	Project duration, Collaborating institutions, Contact address	Main features	Remarks
66	Thai-German Highland Development Programme (TG-HDP)	Tambon Wawi: 14 yrs (1981-1994) Nam Lang: 14 yrs (1984-1998) Huai Poo Ling: 9 yrs (1989-1998) GTZ + Thailand Mr Hagen Dirksen, Regional Advisor Rural Development in Asia Email: hdirksen@loxinfo.co.th	• Reduce drug abuse problem, replace shifting cultivation, maintain ecological balance • Increase subsistence production, appropriate and sustainable land use, soil-water conservation • Integrated and multi-sectoral approach of regional rural development, • Poverty, target group orientation, strengthening organisations, participation, sustainability	• Relevance-B • Very limited info at hand. Dr Dirksen sent 2 web addresses.
67	Rural development in Bokeo Province	- (Initiated in 1994) GTZ + IFAD + Laos No contact address. Written to BMG for further information on 16 Aug.	• Social and economic improvement, ethnic minority, sustainability • Technology (Crops, livestock, fruits, agro-forestry) development, extension, education/training, infrastructure, health, institutional support • Project evaluation report pointed out the failure of the project in achieving several of the project objectives.	• Relevance-B • Very limited information at hand.
68	Land reclamation in Ningxia Hui autonomous region, Peoples Republic of China.	4 yrs (1993-1997) EC + China AHT International GmbH Huyssenalle 66-68 D-45128 Essen, Germany Or, (PO Box 100132, D-45001 Essen) email: aht@aht-inter.com	• Improve water management and agricultural practices in marginal lands • Food security, increase income and living standard • Focus on improving irrigation system, reducing leaching loss, and reclaim salinity	• Relevance-B • Very limited information at hand.

Note: Descriptors of the category

A = Very good for project review purpose, so select. Projects with most of the following features have been considered in this category:

- Relevant project.
- Longer duration project.
- Completed project.
- Project information/reports available to other interested individuals/institutions.

B = Good for project review purpose, so select. Projects with most of the following features have been considered in this category:

- Relevant/partly relevant project.
- Longer duration incomplete project/ short duration completed project.
- Some project information/reports available to other interested individuals/institutions.

C = Not very relevant for project review purpose, so select only in case of inadequate projects available in A and B category. Projects with most of the following features have been considered in this category:

- Less relevant project.
- Short duration project.
- Incomplete project.
- Few project information/reports available to other interested individuals/institutions.

NR = Not Relevant for project review purpose, so do not select. Projects with most of the following features have been considered in this category:

- Not relevant project.
- Short duration project.
- Incomplete project.
- Very few project information/reports available to other interested individuals/institutions.

Relevant = Project with following features were considered relevant:

- Aimed at addressing the following themes:
- Sustainable agriculture
- Soil erosion
- Poverty
- Food security
- Participatory approaches
- Multidisciplinary
- Implemented in sloping land/upland
- Implemented in South-East Asia
- Implemented during the last decade

Annex 2.2: **Sloping Agricultural Land Technology (SALT).**

Contour hedgerow intercropping technology or Sloping Agricultural Land Technology (SALT) is a soil conservation-oriented farming system developed by the Mindanao Baptist Rural Life Centre (MBLRC) in the South Philippines in the mid 1970s. The SALT technology was developed in order to address the need of upland farmers in the Philippines for the farming technology that could conserve topsoil and, if possible, improve its fertility and productivity. The SALT philosophy underscores the fact that sustainable land use maintains an acceptable level of production and, at the same time, conserves the basic resources on which production depends. This technology involves planting double hedgerows of nitrogen-fixing plants along the contour lines on the slope at a distance of 4-6 m. The trees and shrubs planted in hedgerows are trained in a shrubby form to grow in association with annual or perennial crops in spatial arrangement. The space between the contour hedgerows, the alley, is used for agricultural and cash crops. The plants for the hedgerows are selected according to the need for fuel or fodder as also for their soil conserving attributes. Additionally, farmers can also grow cash plants, which helps to increase farm income, facilitates multiple use of the land, and provides opportunities for marginal farmers to improve their living standards. The plants for the hedgerows are selected according to the need for fuel or fodder and for their soil-conserving attributes. Additionally, farmers can also grow cash plants, such as mulberry, within the double hedgerows on each contour line. This technology, therefore, helps to increase farm income, facilitates multiple use of the land, and provides opportunities for marginal farmers to improve their living standards. SALT can be established on farmland with a gradient ranging between 5-25% or more.

MBLRC has evolved four SALT systems, based on the production of food crops, some cash crops, forage species, timber species and raising animals within the farm biomass production cycle, which are:

1. *SALT-1:* focuses mainly on food crop production;
2. *SALT-2:* incorporates livestock with crop farming;
3. *SALT-3:* a system based on additional marginal land that cannot be cultivated but which can be converted into economically productive forest to supplement production from other SALT components; and
4. *SALT-4:* places emphasis on orchard and plantation crops.

The following are the characteristic features of SALT farming systems.

- A biological option for soil conservation.
- An alternative to mechanical terracing.
- A promising system for sloping land farming.

Salient features of SALT farming:

- It is environmentally sound and ameliorating, because of the nitrogen-fixing capacity of the hedgerows, and protective because hedgerows are coppicing tolerant, can perform the mulching function, protect the soil from rain, and preserve soil moisture.
- It is economically rational because it facilitates maximum and efficient use of land and labour; it facilitates regular income generation and multiple benefits through marketable products, provided the plant species are carefully selected.
- It is developmentally desirable, for it has shown the potential to ensure security of food and income to farmers, diversity of products (food, cash income and fodder), higher frequency of harvest, and reduced risk of price fluctuation compared to low-value, high-volume crops, besides sustaining high productivity.
- SALT is more productive per unit of both land and labour than traditional farming practices, provided the system is set up and managed along the lines of the defined norms.

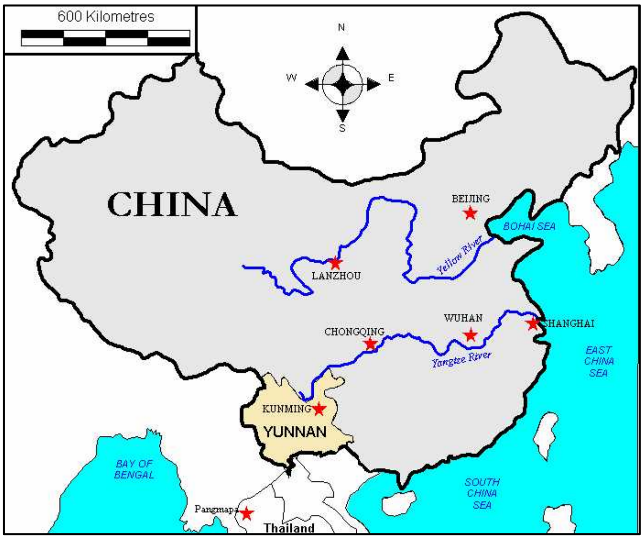
- SALT is technically a relatively simple system that can be replicated easily by upland farmers using local resources and without requiring costly external inputs.
- SALT is a diversified system and, as such, is less risky and more flexible than conventional farming practices.
- SALT is cheaper than terracing in terms of both establishment and operational costs; in addition, it can be applied to situations in which terracing is not, or is no longer, feasible.

Source: (Pratap and Watson 1994; ICIMOD 1999; Tang Ya 1999).

Annex 4.1

Sustainable Highland Agriculture in South-East Asia (SHASEA)

CONSOLIDATED SCIENTIFIC REPORT



Location of Pangmapa and Kunming

1. OBJECTIVES

The main aim of this Project was to increase, in a sustainable and environmentally friendly way, the productivity of wheat, corn (maize) and soybean grown on fragile hill slopes in the highlands of South China and North Thailand. The twin objectives of increased crop productivity and sustainability were to be achieved by the development and scientific evaluation of modified and novel cropping practices in representative highland catchments in South China and North Thailand.

The main study was within the 50 ha Wang Jia Catchment of Kedu Township in Yunnan Province, China, where a fully integrated study of the effects of improved cropping techniques was conducted from 01/01/1999 to 31/12/2002. Several crop management techniques were implemented and a primary goal was the quantitative scientific evaluation of their effects on crop productivity and environmental sustainability. A related goal was to quantitatively assess the socio-economic effects of improved crop productivity. Preliminary plot studies, conducted jointly by the University of Wolverhampton (Partner 1) and Yunnan Agricultural University (Partner 5), suggested mulching techniques could improve corn and soybean yields and thus increase farm incomes by *circa* 10% (160 Euros per ha), while maintaining soil fertility. A goal was to assess the validity of this hypothesis and an objective was to achieve significant improvements in income to assist the alleviation of poverty.

A parallel study, restricted to scientific evaluation of agronomic and physico-chemical impacts, was carried out in a highland experimental site in North Thailand (Pangmapa). An objective was the direct and continual exchange and comparison of research information and data between the two research sites, which would fulfil the objective of testing the broader applicability of the cropping practices for South-East Asia.

1.1. Expected Outcomes

(i) A complete scientific study and evaluation of the effects of novel combinations of cropping and cultivation systems on the productivity of key arable crops (wheat, corn and soybean), with enhanced sustainability in fragile highland areas in South China. The feasibility of applying selected techniques to the highlands of North Thailand would also be evaluated.

(ii) Evaluation of the socio-economic effects of recommended cropping strategies, including their applicability, acceptance, benefits and development implications at the individual farm level and their impact on the wider community (village, township, province and region).

(iii) The full establishment of a functional integrated catchment study, which would serve as an observatory and model and be maintained as a long-term research, training, extension and demonstration facility, subject to the availability of funding. A longer-term management plan for the catchment will be agreed, on which further actions and recommendations for wider adoption and adaption will be based.

(iv) International dissemination of research information and technology.

(v) The relaying of recommendations and information directly to local farmers and farm workers in a culturally acceptable manner (open days with field visits by local farmers, educational booklets for farmers and training for agricultural advisers in Yunnan). Because of the timescale of the research, this outcome will continue beyond the funded period of the programme.

2. ACTIVITIES AND METHODOLOGY

Activities and methodology included:

(a) The measurement of current productivities of corn, wheat and soybean on fragile slopes in both catchments, plus identification and semi-quantification of soil erosion processes.

(b) A full environmental assessment of Wang Jia Catchment.

(c) Implementation and evaluation of modified and novel crop practices designed to increase crop yields and reduce soil erosion on fragile slopes at the research sites in both China and Thailand.
(d) Initiation of the assessment, which will be ongoing, of the environmental impacts of the changed practices on Wang Jia Catchment and the socio-economic impacts on the adjoining village of Kelang.
(e) Initiation of the dissemination of Project outcomes, which will be ongoing, across the applicable highland areas of South-East Asia.

The work was divided into five work packages, which addressed the following areas:
1. Agricultural and environmental evaluation of Wang Jia Catchment (WP1).
2. Implementation and evaluation of modified and novel cropping systems (WP2).
3. Evaluation of the socio-economic effects of cropping strategies (WP3).
4. Comparative evaluation of cropping practices at the Pangmapa Site in North Thailand (WP4).
5. Information and technology dissemination (WP5).

Work Package 1: Agricultural and Environmental Assessment of Wang Jia Catchment

Co-ordinated by Partner 4, Gembloux Agricultural University, Belgium (GAU).
(i) Full survey and review of existing catchment information.
(i) Baseline crop productivity measurements.
(ii) Full land use and geomorphological survey, using remote sensing data (LANDSAT and SPOT imagery).
(iii) Field topographic and vegetation survey.
(iv) Soil survey and construction of a detailed map (1:10 000) soil map (Annexe 2).
(v) Full chemical and mineralogical analysis of soil samples to assess soil nutrient, fertility and erodibility status.
(vi) Production of a catchment description.

Originally, a hydrological survey was included in the project plan, using in part data provided by two flow stations to be installed at the top and bottom of the catchment. In the end, only one station at the base of the catchment was installed (see Section 4).

Work package 2: Implementation and Evaluation of Modified and Novel Cropping Systems Co-ordinated by Partner 5, Yunnan Agricultural University (YAU).
(i) Development and scientific evaluation of modified and novel cultivation techniques to improve the productivities of corn, wheat and soybean on sloping land in the catchment. This included use of contour cultivation, straw mulch, minimum tillage, plastic mulch and a novel combination of mulching techniques and intercropping.
(ii) Implementation of improved water conservation and irrigation management systems. This included construction of engineering measures to stabilise gullies and reduce the risk of flooding.
(iii) Development and implementation of alternative cropping strategies to contribute to the improvement of economic returns, erosion control and agricultural sustainability in the catchment. This included the use of tree cash crops (sweet chestnut and prickly ash) and re-forestation (Chinese pine) on the steeper slopes. Grass strips were used as erosion control measures on the cultivated slopes.
(iv) Production of a catchment management plan, following the full analysis of the scientific and technical evaluations, with inputs from the other work packages.

The outcomes from both WP2 and WP1 will be supplemented by PhD theses to be produced over the next year by Wang Shu Hui and Li Yong Mei.

Work Package 3: Evaluation of the Socio-Economic Effects of Cropping Systems

Co-ordinated by Partner 3, The National University of Ireland, Galway (UoG).

(i) Development of crop budgets for the investigated cropping and cultivation techniques.
(ii) Cost-Benefit Analysis (CBA) at farm level on the various alternative crop cultivation techniques and identification of the optimum combination.
(iii) Assessment of farmers' attitudes to alternative options, including the optimum crop cultivation technique.
(iv) Assessment of the socio-economic impact of alternative crop cultivation practices on the wider community.
(v) Prescription of local and regional policy recommendations for farmers.

Work Package 4: Comparative Evaluation of Cropping Practices to Improve Soil Productivity on Highland Slopes in Thailand

Co-ordinated by Partner 7, Chiang Mai University (CMU).

(i) Evaluation of the agronomic effectiveness of selected cropping techniques on the production of corn and lablab bean.
(ii) Inclusion of contour cultivation, contour ridge cultivation, contour ridge with polythene and straw mulch and alley cropping in the evaluation.
(iii) Investigation of treatment impacts on soil fertility and structure, soil loss and runoff, water storage, water use, growth rate yields and water use efficiency of the crops.
(iv) Initial assessment of the feasibility of applying the most effective techniques to agricultural development in the Thai highlands.

Work Package 5: Information and Technology Dissemination

Co-ordinated by Partner 1, the University of Wolverhampton, U.K. (UoW)

(i) Production and distribution of verified databases and season/year reports.
(ii) Development of the WWW site.
(iii) Local liaison meetings with farmers and township leaders.
(iv) Regional conferences, open days at Wang Jia Catchment and promotions.
(v) Development of procedures to contribute to the production of training materials.
(vi) Contribution to the development of long-term cropping plans for Wang Jia catchment.
(vii) Production of papers for international conferences and refereed journals.

3. RESULTS ACHIEVED

Work Package 1: Agricultural and Environmental Assessment of Wang Jia Catchment

Catchment Geomorphopedology

Partner 4, Gembloux Agricultural University

The main results achieved included the improvement of the existing topographic map to produce a digitised catchment map, georeferenced in the UTM projection system, which is the base document for all thematic maps produced, such as the land use map or the plantation map. The representativeness of Wang Jia Catchment was evaluated by comparing its geomorphological and land use characteristics with those of the whole mountainside south of Kelang village, in which it is included. The comparison between hypsometric curves, slope classes, SPOT satellite image interpretation (coloured image composition, image classification, vegetation index) showed that Wang Jia is representative of the Kelang mountainous area. A detailed catchment landuse map was built from observation by field survey and aerial photographs. Lithological and geomorphological surveys were also carried out, including catchment geology and catchment geomorphology. This included an assessment of erosion and an investigation of soil physics, specifically water availability for plants. Soil identification and soil fertility evaluation allowed a geomorphopedological synthesis to be produced in the table-legend of the geomorphopedological sketch produced for the catchment. Reference plots ensure a link with socio-economic data gained at the farm level.

The study shows that, due to erosion on convex and steep linear slopes and to accumulation in concave positions, soils are young and show strong evidence of rock heritage. This is expressed by illite and chlorite as dominant clay minerals, a silt texture and a yellowish brown colour on slopes with sandstone and shale outcrops. A red clay material with some haematite, kaolinite and gibbsite seems to be trapped in a palaeokarst. However, from upstream to downstream and from top- to downslope, the colluvial mixing increases, the texture becomes finer, the soil colour darker (except in the catchment outlet) and soil pH increases. This has a direct impact on relatively high soil potentialities, plot fertility ranging from dystric (low fertility status) to eutric (high fertility status).

Chemical and Mineralogical Analyses of Yunnan Agricultural University and Pangmapa Soils and a Comparison with those from Wang Jia

Partner 2, the Macaulay Land Use Research Institute, U.K. (MLURI)

In general, the results suggest that the soils from areas close to the experimental plots and to the excavations made for the water reservoirs (54 samples from 19 different soil profiles plus samples of parent material) are still strongly influenced by the geological parent material from which they are derived. Optical microscopy confirmed the presence of free carbonate minerals in the soils, in addition to other weatherable primary minerals such as biotite and chlorite. X-ray diffraction (XRD) studies of the <2µm fraction of some parent rocks showed a predominance of chlorite and mica, as well as an absence of kaolinite, exactly reflecting the major clay mineralogy found in the catchment soils. Preliminary SEM observations were also made on the nature of the water stable aggregates separated from selected catchment soils. Various types of soils aggregate could be identified including (a) compact or loose clay-rich aggregates with discrete segregations of iron or manganese oxides, (b), compact aggregates of sandy grains embedded in, or coated by, clayey material and (c) compact to loose aggregates containing carbonate grains and various kinds of decomposed organic matter. They were thought to correspond to formation of water stable aggregates though binding by oxides, clayey material and organic matter.

Six benchmark soil profiles were sampled from the various landscape units of the catchment, in addition to a profile from YAU experimental plots. Profiles 1 and 2 were sampled from the upper part of the catchment. Both soils are of a yellowish brown colour and tend to be acidic in reaction towards the surface, with a pH of <5.5 and base saturation of <50%. They were classed as Inceptisols (Dystropepts) and from the mineralogical data it was concluded that they showed little evidence of intensive weathering. Profiles 3, 4 and 5 occurred mainly in the intermediate sector of the catchment. The soils are now more reddish in colour and are of a higher pH with higher levels of base saturation, depending on the nature of the parent material. Profile 6 occurs in the lower part of the catchment near to the outlet and Kelang village. The soil is yellowish brown to yellowish orange in colour, has a pH always >7 and is fully base saturated throughout. The clay mineralogy is identical to that of Profiles 4 and 5. In general, it may be concluded that the chemical characteristics of the YAU soil profile are incompatible with a classification within the Ultisol order (high pH values and base saturation percentages, presence of free carbonate and moderately high organic matter content). On the other hand, the clay mineralogy of the soils is quite consistent with such a classification.

At the commencement of the Project, it was believed that the soils at both the Wang Jia and YAU experimental sites could be classed as Ultisols, according to the US system of Soil Taxonomy. In fact, most of the soils classified as “Red Soils” according to the Chinese system of soil classification would indeed be regarded as Ultisols. However, Project investigations indicated that the Wang Jia soils cannot be classified as Ultisols and are, therefore, not representative of most red soils in southern China and South-East Asia which fall firmly into this category. Partner 4 suggested that these soils should be more appropriately viewed as Alfisols or even Inceptisols, and the evidence presented in the report is generally consistent with this suggestion. An important feature of the Wang Jia soils is that they are essentially colluvial in nature. This means that they are continually being replenished by material moving downslope. It is probable that this provides the explanation for the variation in clay mineralogy found in different parts of the catchment. The upper catchment would be continually subject to mass movement further downslope. Any weathering mantle that does form here would be subject to this movement and would tend to accumulate in the middle and lower parts of the catchment. Hence, soil mineralogy at the head of the catchment is dominated exclusively by contributions from parent rock, whilst the soils in lower parts of the catchment additionally contain contributions from previous weathering episodes. It may be concluded that it would be unwise to extrapolate uncritically the results from the cropping experiments on soils of Wang Jia Catchment to other red soil areas of southern China or South-East Asia, which are inherently less fertile and subject to a much wider range of soil constraints with regard to crop growth. This would also apply to the cost/benefit analysis undertaken for the cropping strategies in Wang Jia Catchment.

Mineral Magnetic Properties of Soils from Wang Jia Catchment

Partner 1, the University of Wolverhampton, U.K. (UoW)

The mineral magnetic data show the magnetic properties of the soils are similar to some igneous rocks and coarse metamorphic rocks, with most samples containing a moderate to high concentration of magnetic minerals, most of which are magnetically soft (i.e. magnetite-type minerals) and display a dominance of superparamagnetic grain size. Typically, these characteristics are chiefly indicative of ferrimagnetic minerals. Based on this information, and the other partners' knowledge of the mainly limestone bedrock geology, it is inferred that *in situ* secondary magnetic minerals must be enhancing the magnetic signature of these soils beyond the magnitude of the signature of the magnetically weak parent material, to produce the moderate to high concentration of magnetic minerals. Furthermore, mineral magnetic measurements have previously been used to trace the movement of soils and sediments, and in light of the interpretations proposed by the other partners, it is proposed that future work could employ magnetic measurements to monitor mass movement and, in doing so, be used to quantify soil erosion throughout the catchment.

Conclusion for Work Package 1

All sites show evidence of erosion on convex and steep slopes and of accumulation in concave positions. The fact that all three sites are on soils dominated by the influence of limestone and strongly affected by contributions from material further upslope means that they can be compared with confidence and that the results of the cropping experiments can be extrapolated to areas of a similar nature. Such areas are extensive in the highland regions of Yunnan Province and South-East Asia.

Work Package 2: Implementation and Evaluation of Modified and Novel Cropping Systems Partner 5, Yunnan Agricultural University and Partner 6, the Government of Kedu Township, China

Before the modified cropping systems could be implemented, substantial engineering works were carried out to stabilise gullies and reduce the risks of flooding in the catchment. A water conservation and irrigation system was constructed following detailed discussions with catchment farmers who identified water availability as a major factor limiting crop productivity in the catchment. These measures have been successful in limiting severe erosion processes in the catchment, improving safety both in the catchment and in the village. The irrigation scheme has provided the basis for achieving more reliable improvements in crop productivity, in conjunction with the modified cultivation practices.

Alternative cropping strategies were also identified and implemented, in collaboration with catchment farmers, to improve erosion control, enhance long-term economic returns and improve the sustainability of agricultural practices in the catchment. These measures included the planting of tree cash crops (sweet chestnut and prickly ash) on the steeper slopes, re-forestation (with Chinese pine) of the top of the catchment which was unsuitable for continuing cultivation, and the use of grass strips as erosion control measures in cultivated areas. Long-term evaluation of the impact of these measures is on-going.

However, the primary focus of the work has been the scientific evaluation of cultivation practices for improving the productivity of corn. These were selected and developed from practices evaluated previously in erosion plots for their effectiveness in soil conservation. These were: (i) traditional cultivation with downslope planting (D); (ii) traditional cultivation with contour planting (C); (iii) traditional cultivation with double ridge contour planting and polythene mulch (C+P); (iv) traditional cultivation with double ridge contour planting, polythene mulch and straw mulch (C+P+S) i.e. the **INCOPLAST** treatment; (v) traditional cultivation with contour planting, polythene mulch and intercropping with soybean (C+P+IS). The main conclusions are:

1. The control treatment (D) produced yields in the range 4-7 t/ha, with a mean (three cropping seasons, three replicate plots) of 6.7 t/ha, which is above the average corn yield for Yunnan Province of 3.9 t/ha.
2. The contour treatment (C) produced yields in the range 5-8 t/ha, with a mean of 7.6 t/ha. In most experiments, the mean value was not significantly different from treatment D.
3. The polythene treatment (C+P) produced yields in the range 8-12 t/ha, with a mean of 9.6 t/ha. These yields were no greater than those obtained in an earlier experiment, reported elsewhere, for a single ridge polythene mulch system.
4. The addition of straw mulch between the ridges (C+P+S), produced no significant additional increases in yield over C+P.
5. Intercropping with soybean (C+P+IS) produced yields in the range 8-10 t/ha, with a mean of 9.3 t/ha, which was not significantly different to either treatment C+P or C+P+S.
6. Over a three year period, the mean yield responses were:

Treatment	D	C	C+P	C+P+S	C+P+IS
Yield (t/ha)	7.0	7.8	9.6	9.6	9.3
%	-	11.4	43.3	43.3	38.8

   Physical measurements suggest that the increased crop response may be due in part to higher soil temperatures and improved soil moisture retention in the early season. Pre-irrigation in advance of the onset of the rainy season, followed by mulching treatment, is particularly beneficial. This enables rapid crop development and thus high crop yields. Furthermore, rapid development of vegetative cover, especially corn canopy closure, is highly beneficial for resource (soil, water and nutrient) conservation.
7. In a separate experiment using erosion plots, reported elsewhere, the C+P+S treatment was the most effective for soil and water conservation, producing least runoff and soil loss.
8. Therefore, in terms of increasing corn productivity, the most effective treatments were C+P and C+P+S, with no apparent advantage from using double ridge or straw mulch. For soil and water conservation, C+P+S was significantly more effective than C+P, suggesting the former would achieve the best combined performance of increasing yields and improving soil and water conservation. However, it has not been possible to quantify the magnitude of these conservation benefits under the conditions existing in the catchment. The additional inputs required for C+P+S (**INCOPLAST**), in terms of straw mulch and labour to install the double ridge compared to a single ridge, could only be justified on technical grounds if achieving improved soil and water conservation was a high priority.
9. The increased yields obtained from the use of polythene mulch, with or without straw, have been maintained over four years. Therefore, the technique appears to be agronomically sustainable in the short term, but a longer period of monitoring is necessary to determine the long-term effects on soil fertility and structure.

10. The relatively high corn yields obtained in this study (more than twice the yield in Yunnan Province (Zhou Kaillian, *pers. comm*., 2002) have been achieved through the use of high levels of manure and inorganic fertilisers, with irrigation supplied when necessary to offset early season drought. Detailed cost benefit analysis is required to determine if the more labour-intensive techniques and additional inputs required are offset by the value of the increased yield.
11. The yields of the winter wheat crop were still low because of very low winter season rainfall, but the availability of irrigation water as a result of the Project increased the reliability of the crop, which could then be used to provide straw mulch for the summer corn crop.

Recommendations are listed in Section 7.7.

Work Package 3: Evaluation of the Socio-Economic Effects of Cropping Systems

Partner 3, National University of Ireland, Galway

Kelang Village has moved from a heavy dependence (70%) to a low level of dependence on agriculture over a few years. This is significantly influenced by government policy to reduce tobacco production, agricultural prices and the availability of off-farm employment. However, for some families (11%), agriculture is still the main source of income. There is a very high positive correlation between the level of household income in Kelang and engagement in off-farm employment. There is also significant opportunity for off-farm employment both in Kelang and Kunming and there is a strong preference for off-farm employment among adults, both for themselves and for their children. Indeed, there is a high level of interest (25%) in moving out of Yunnan Province for off-farm employment.

An evaluation of integrated catchment management practices reveals that the long-term impact of these practices is positive, although there are net costs in the early years. However, the time preference of farmers is strong, particularly among the poorer farmers who are more likely to be heavily dependent on agriculture for their livelihood. This means that unless farmers can be persuaded of the desirability of environmental measures, or compensated for engaging in them, they are unlikely to implement them of their own accord. Farmers are becoming less dependent on agriculture as their primary source of income. Income derived from upland agriculture is less than 50% of total on-farm income, or 15% of their total income. Environmental and related productivity measures relate to these uplands. The increased effort and expenditure for a long term return on these uplands is not attractive for farmers and is likely to be less so as alternative off-farm employment becomes increasingly available. However, the negative impact of doing nothing about erosion goes beyond the farming community and the local area. Farmers' preference for higher value-added crops means that they are unlikely to voluntarily commit more time and labour to improving corn cultivation techniques, without clear policy directives and possible financial incentives.

Given the declining importance of agriculture, the small amount of land involved and the fact that farmers would not choose to grow corn, given a choice, the effects of the new cultivation practices on the region as a whole are unlikely to be profound. If widespread adoption of environmentally sustainable agriculture on upland slopes is desired, then the government needs to provide incentives to farmers to engage in the new practices. A number of policy recommendations emerged from this work that are listed in Section 7.7.

Work Package 4: Comparative Evaluation of Cropping Practices to Improve Soil Productivity on Highland Slopes in Thailand

Partner 7, Chiang Mai University

The agronomic and physico-chemical impacts of a selected alley cropping system on soil fertility, soil erosion, water conservation and crop yields were compared with the impacts of three other contour cultivation (cultural) practices during 2000-2002. The studied cultivation practices were (i) conventional contour planting, CC, (ii) contour ridge cultivation without mulching, CR, (iii) contour ridge cultivation with polythene + straw mulch, **INCOPLAST** or CRP and (iv) alley cropping with mango and Graham Stylo (*Stylosanthes guianensis*) as hedgerow, AL. Corn (*Zea mays*) was grown during May-September, followed by lablab bean (*Lablab purpureus*) during September-February, on the CC, CR, CRP and AL plots, under a completely randomized experimental design with three replicates each year. The plot was located in Jabo Village, Pangmapa District, Maehongson Province, on a hill slope of 35%, latitude 19^o 33' 47" N, longitude 98^o 12' 9" E and altitude 780 m. Soil water stored within 1700 mm was monitored every 2-3 weeks by neutron moisture meter. Runoff and erosion were measured after every rainstorm. Soil sampling and analysis were conducted one month after sowing and one month before harvesting corn. Crop development was measured as total dry biomass at different growth stages of corn and lablab bean, crop yields were harvested as dry seeds, seed+cob (pod) and total dry-matter.

The three year mean values of seasonal soil erosion and surface runoff obtained on CC, CR, CRP and AL plots were 13.47, 12.53, 8.30 and 5.23 t ha^{-1} of soil loss, and 128, 114, 127 and 86 m^3 ha^{-1} of runoff, respectively. The highest seed yield of corn was produced on AL plots, while the highest yield of lablab bean was obtained on CRP plots compared to those obtained from CC or CR during the three years of the experiment. The mean seasonal seed yields given by CC, CR, CRP and AL practice were 7.42, 7.44, 8.66 and 9.87 t ha^{-1} of corn, and 227, 187, 314 and 267 kg ha^{-1} of lablab bean, respectively. The three years of experimental results indicated that AL was the most conservative method and the best practice for improving corn yield, reducing runoff and erosion on highland slopes. CRP was the second best for both corn yield production and erosion control, but it was the best for conserving soil water, giving the highest water use efficiency and lablab bean yield during the dry season.

Work Package 5: Information and Technology Dissemination

Partner 1, University of Wolverhampton

The research team adopted a balanced and integrated strategy for maximum information dissemination. Detailed plans agreed for *'Information Dissemination'* include a sequential and phased plan of research output in local media, agricultural journals and international conferences, to be followed by general papers in international refereed journals. Information on the **SHASEA** Project can be accessed on the World Wide Web. These pages are regularly updated and the URL is: http://www.wlv.ac.uk/science/environment/SHASEA/

Two Ph.D. theses, 11 Masters theses and 12 B.Sc. theses associated with the Project have been completed. Furthermore, three Ph.D. theses are in progress, along with two M.Sc. projects. Papers reporting the research to date in South-East Asia, have been presented at conferences in Bangkok (Thailand), Barcelona (Spain), Buenos Aires (Argentina), Chiang Mai (Thailand), Glasgow (U.K.), Hamburg (Germany), Kunming (China), London (U.K.), Manila (Philippines), Merano (Italy), Montpellier (France), Müncheberg (Germany), Munich (Germany), Purdue (U.S.A.), Reading (U.K.), Rio de Janeiro (Brazil), Seattle (U.S.A.) and Valencia (Spain). A major component of Work Package 5 is sustained publication output in high quality international journals. After the initial Conference presentations, the team is preparing introductory published papers for international refereed journals, and is increasingly in a position to publish detailed papers stemming from individual Work Packages in high profile international journals.

In the final year of the Project, the team organised the '*Workshop on Sustainable Highland Agriculture in South-East Asia* (**SASEA**)' in Yunnan, China. The main aim was to introduce the research findings of the Project to potential users. It targeted and integrated research users, policy-makers, the scientific research community, local farmers and extension workers and had two components: one a post-Congress tour ('*Red Cloud Tour'*) of the '17th World Congress of Soil Science', Bangkok, Thailand (August 14-21, 2002); the other a workshop at Kunming, Yunnan Province. This aimed to promote the practical applications of the research for improving the productivity and sustainability of cropping techniques on fragile highland slopes in South-East Asia in an environmentally friendly way. The Workshop was supported financially by a successful 'Accompanying Measures' application, made to the EU. To aid dissemination of Project research results, the team prepared the '*Red Cloud Tour Guidebook'*, plus an updated project pamphlet in English and Chinese and an instructional manual in Chinese. The Project was also represented at the 'China Hi-Tech Fair' (Shenzhen, 2002) under the aegis of the EU delegation.

A series of field workshops has been held in Wang Jia Catchment since October 2000, planned to relate to critical times in the cropping season. The results from field experiments are discussed and improved cropping procedures demonstrated. These workshops have generated considerable interest and discussion.

4. PROBLEMS ENCOUNTERED

1. The hydrological characteristics proved, following studies initiated in the first year, to be far more complex than originally envisaged and were not amenable to detailed study using the planned methodologies. Therefore, this part of the programme was not fully developed.
2. There were considerable delays, associated with the importation of equipment into the region of study, which limited the use of automatic weather recording and micro-meteorological monitoring until the final two years of the Project.
3. There were several changes in the village and township leadership (Partner 6) during the Project, which made the development of consistent management strategies more difficult. Some approaches had to be revised in order to accommodate local policy changes
4. There were unavoidable delays in appointing Chinese researchers for parts of WP1 and WP2, which has meant that some of the original objectives, in terms of catchment measurements were not completed as scheduled. Some of the work is ongoing and will be completed over the next year supported by YAU, UoW and GAU. For example, a full analysis of catchment productivities over the project period is still in progress.
5. There were delays, partly because of changes in village leadership (see 3) and partly because of delays in appointing Chinese-speaking researchers with the appropriate expertise, in developing the socio-economic methodologies for household assessments in Kelang Village. This meant that the baseline study was not carried out as early as originally intended.
6. There were changes in Provincial Government policy in relation to the cultivation of tobacco, the major cash crop in the region, which had implications for the development of cultivation strategies for the food crops under study. These impacts were beyond the control of the Project team and will influence longer-term catchment management decisions.

5. TECHNOLOGY IMPLEMENTATION PLAN

Experimental results are being widely disseminated to assist sustainable agricultural development, using a variety of media. This fully accords with stated EU policy aimed at promoting sustainable development and poverty alleviation. The Technology Implementation Plan is being co-ordinated at international, national and provincial levels:
<u>International:</u> Publication of papers in international refereed journals, presentation of results at international conferences and dissemination of recommended techniques on the world-wide web.
<u>National:</u> Training of Ph.D. and M.Sc. students (in Belgium, China, Ireland, The Netherlands, Thailand and the U.K.) and presentation of the 'Kunming Workshop' in September 2002.
<u>Provincial</u>: Since 1999, incorporation of project activities into the training programme of B.Sc. and M.Sc. students at Yunnan Agricultural University. On graduation, most of these students become agricultural advisors within Yunnan Province and incorporate project results into their advisory programmes. Furthermore, there has been wide dissemination of project results, both within the Yunnan Provincial media (newspapers and TV) and in

participatory field sessions with farmers. Direct collaboration with the Yunnan Province Soil Conservation Service has ensured results are disseminated to the Service and they are being directly used in the design of Provincial soil and water conservation programmes.

6. PUBLICATIONS AND PAPERS

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4. Fullen, M.A. (plus the **SHASEA** team) 2001. Multidisciplinary approaches to soil conservation in the highlands of South China and Thailand, p. 139-145 In: K. Helming (Ed.), *Multidisciplinary Approaches to Soil Conservation Strategies*, ZALF (Zentrum für Agrarlanschafts- und Landnutzungsforschung e.V.), Müncheburg, 191 pp.
5. Panomtaranchagul, M., Sukkasem, C., Peukrai, S., Fullen, M.A., Hocking, T.J. and Mitchell, D.J. 2001. Comparative evaluation of cultural practices to conserve soil and water on highland slopes in northern Thailand, p. 147-152 In: K. Helming (Ed.), *Multidisciplinary Approaches to Soil Conservation Strategies,* ZALF (Zentrum für Agrarlanschafts- und Landnutzungsforschung e.V.), Müncheburg, 191 pp.
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7. Fullen, M.A. (On behalf of **SHASEA**) 2001. An integrated approach to soil conservation in an experimental watershed in the highlands of South China. In: *Proceedings of the 3rd International Conference on Land Degradation,* Rio de Janeiro (CD-ROM).
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13. Xu Sheng Guang (on behalf of SHASEA), 2002. Effect of surface mulch and contour-planted maize on soil water temperature on sloping croplands with red soils. *Journal of Yunnan Agricultural University*, 17(3) 220-224. (In Chinese)
14. Cai Cheng Zhi (on behalf of SHASEA), 2001. Effect of different cover treatments on soil temperature and maize yield on sloping land. *Tillage and Cultivation*, 6, 41-43. (In Chinese)

15. Cai Cheng Zhi (on behalf of SHASEA), 2002. Effects of contour cultivation and mulching with polythene film on growth and development of maize grown on sloping land. *Southwest China Journal of Agricultural Science*, 15, (2) 38-41. (In Chinese)

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2. E. Milne 2001. *Soil conservation in relation to maize productivity on sub-tropical red soils in Yunnan Province, China*. Ph.D. thesis, The University of Wolverhampton, 271 pp.

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2. O'Shea, R. 1999. *Agricultural reform in China: A review of village level impacts*. Master in Applied Economics dissertation, The National University of Ireland (Galway), 67 pp.
3. Wenjun, Cui. 1999. *The economics of rural-to-urban labour migration in China in the post-1978 Period*. Master of Economic Science dissertation, The National University of Ireland (Galway), 58 pp.
4. Xu Sheng Guang 2000. *Effects of surface mulch and planting direction on soil physical and chemical properties and maize*. M.Sc. dissertation, Yunnan Agricultural University, 98 pp. (In Chinese, with English abstract).
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8. Baire, S. and Ghuisoland, J.G., 2001. *Contribution à l'établissement d'un système de référence sur les sols et leurs occupations en vue de leur gestion durable. Bassin de Wang Jia, Yunnan, Chine*. (*Contribution to the implementation of a soil and land use reference system in view of their sustainable management. Wang Jia Catchment, Yunnan, China*. M.Sc. Thesis). M.Sc. dissertation, Gembloux Agricultural University, 123 pp. (Note: this thesis was awarded the grade of *'Grande Distinction'*).
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2. Milne, E.; Fullen, M.A.; Hocking, T.J.; Mitchell, D.J.; Zhao Yan; Wu Bo Zhi and Liu Liguang 2000. Soil conservation measures in relation to crop productivity on arable sub-tropical Ultisols in Yunnan Province, P.R. China. *Poster paper presented at the Association of Applied Biology* Conference, Reading (22/03/00).
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7. Fullen, M.A. (On behalf of **SHASEA**) 2001. Multidisciplinary approaches to soil conservation in the highlands of South China and Thailand. Paper presented at the

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1. **SHASEA** (The Sustainable Highland Agriculture in South-East Asia Research Team) 1999. *Improving the productivity and sustainability of crop systems on fragile slopes in the highlands of South China and Thailand*. Progress Report 1 (Periodic) to the European Commission under Contract Number ERBIC18 CT98 0326, 15 pp.
2. **SHASEA** (The Sustainable Highland Agriculture in South-East Asia Research Team) 2000. *Improving the productivity and sustainability of crop systems on fragile slopes in the highlands of South China and Thailand*. Progress Report 2 (First Annual Report) to the European Commission under Contract Number ERBIC18 CT98 0326, 187 pp.
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6.5. Guidebook

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7. CONCLUSIONS

7.1. General Conclusions

1. The scientific aims of the project have been achieved and, within this context, the Project may be considered a “success story”. Specifically:
   It has been demonstrated that the productivity of corn can be increased, by up to 50% compared to traditional methods, on sloping fragile land, using simple cost-effective technologies, which in parallel plot studies have been shown to improve soil and water conservation. A detailed scientific evaluation has been carried out in Wang Jia Catchment to quantify the effectiveness of these technologies and develop explanations of how the crop responses have been produced.

2. Improvements in corn cropping practices have been linked to the on-going development of a land management plan to achieve, in the longer term, a more sustainable agricultural system in Wang Jia Catchment. This plan has included a range of engineering measures to control erosion, the installation of an irrigation system to improve the level and reliability of crop yield, including corn and winter wheat, the planting of trees as cash crops (sweet chestnut and prickly ash) on the steeper slopes, the planting of pine on parts of the upper catchment to return that land to forestry and the development of a monitoring system to attempt to evaluate the effectiveness of these measures over the longer term. Discussions on the further development and maintenance of this plan are continuing.

3. The development of this land management plan has also been informed by a comprehensive survey and description of the biophysical characteristics of the catchment, which has provided a baseline for subsequent change and established the representativity of the catchment in relation to the surrounding area. The catchment has been shown to be representative of the mountainside where it occurs, and the soils at the different sites to be representative of red soils dominated by the influence of limestone and strongly affected by contributions from material further upslope. Such areas are extensive in the highland regions of Yunnan Province and South-East Asia. The description and analysis of the site is ongoing, as the changes to the catchment proceed, and will be developed into a GIS-based land management and evaluation system for subtropical highland catchments, such as Wang Jia.

4. Socio-economic analysis, which is also ongoing, has been used to determine the economic and social feasibility of the alternative cropping strategies, the wider implications of the land use changes and the likelihood of subsequent adoption and adaption of the technologies employed. Moderately long (five years plus) perspectives are needed for investment programmes to yield dividends. Government assistance is needed for the farming community to achieve significant improvements in sustainability over this time horizon.

5. Scientific evaluation of selected cropping practices developed in Wang Jia has been carried out in North Thailand and has demonstrated that these practices are, in most respects, as effective as the best practices in use in that region. In the Thai context, alley cropping was particularly successful in terms of increased crop productivity and soil, water and nutrient conservation.

6. Dissemination and training activities for wider adoption of these practices and associated recommendations have been initiated, first through a series of workshops held in the catchment for farmers in Kelang village and subsequently in the form of training session(s) for local government officials and other stakeholders. This process is ongoing.

7. Scientific training associated with the project outcomes has been achieved through a series of undergraduate, masters and Ph.D. programmes.

8. Dissemination of the scientific outcomes of the project has been achieved through presentations at a number of national and international conferences, a scientific tour of the project catchment, a provincial workshop held at YAU and a series of publications and reports.

7.2. Specific Conclusions from Work Package 1

The objectives established for Work Package 1 have been achieved, with the exception of the hydrological survey, by the appraisal of the catchment biophysical diversity and thus of the representativity of the experimental site for reddish brown soils on dolomite. Moreover, this survey provides a good minimum data set on soils in this relatively unprospected mountainous area. It also provided an opportunity to make Chinese colleagues and practitioners aware of an operational methodology and its associated technologies (field techniques, directional GPS, remote sensing, soil laboratory analysis and GIS).

It seems that even though there are significant differences between the Wang Jia soils and those from YAU and Pangmapa, there are nevertheless sufficient points of similarity, particularly with regard to soil chemistry, to enable valid comparisons to be made. This arises mainly from the dominant influence of the limestone parent rock at all three sites. It is possible, therefore, that this will enable extrapolations from the Wang Jia cropping experiments to be made over a wider area where the soils are developed from limestone and where there is active tectonic uplift. This could represent an area of some considerable size, because this part of South-East Asia is one of the most extensive areas of limestone in the world.

7.3. Specific Conclusions from Work Package 2

During the research period at Wang Jia Catchment, there were significant improvements in soil conservation and increased crop production, whether through engineering, biological or cultivation methods. These included adjusting planting patterns, improving traditional cultivation methods and stabilising the gullies. In general, cropping strategies for improving productivity and soil conservation have been established during the Project.

The establishment of dams along the gully has prevented stream erosion from triggering landsides during the rainy season, thus protecting the general ecology of the area and cultivation fields. However, the effects may be short term and the situation will need to be monitored. The irrigation system in the experimental area ensured sufficient water for early irrigation during the dry season, to enhance corn germination, rapid growth and increased final yield. Depending on the early season rainfall, irrigation at the early stage of corn growth could be very important and increase the potential and reliability for improving crop productivity through the use of modified cultivation practices.

It has been demonstrated that the cropping practices evaluated do increase the productivity of corn under the environmental conditions encountered in the catchment. In seasons where early season rainfall is limiting, these increases can be can be as high as 50%. Parallel plot studies quantified their effectiveness in improving soil conservation but it was not possible to estimate these effects within the catchment. By combining catchment and erosion studies, it is possible to conclude that the practice that will achieve the best combination of increased productivity and improved soil conservation on sloping land is INCOPLAST, an integration of contour planting, polythene mulch on the contour ridges and straw mulch between the rows. This conclusion is based on the scientific/technical evaluation. Cost benefit analysis (WP3) suggests that this practice may be difficult to justify on economic grounds, unless a high value is given to the loss of soil and nutrients by surface erosion.

Grass strips appeared to play a very notable role in reducing soil erosion and contour ridges formed naturally where the grass strips grew, allowing natural terraces to be gradually developed. Applying conservative cultivation practices to arable land, combined with engineering measures (building dams) and biological measures (growing different tree types) on the steeper slopes in the catchment, appeared to protect soil resources and improve the local environment. However, longer-term monitoring is required to evaluate the impact of the biological measures. Water shortage was recognised by the catchment farmers as a key limiting factor to both winter and summer crop production, in common with most highland areas in Yunnan Province. The Project has demonstrated that the availability of irrigation water increased the potential for improvements in crop yields, in combination with modified cultivation practices.

These scientific evaluations have supported the development of a land management plan for the catchment, which has also received inputs from the other Work Packages, as described in the general conclusions. This plan, together with discussions on the maintenance of the catchment as a research and demonstration facility, will evolve as the monitoring of the biological, environmental and economic impacts proceeds.

Recommendations for use of the cultivation techniques in relation to different levels of erosion risk and water shortage are given in Section 7.7.

7.4. Specific Conclusions from Work Package 3

Research results show that the long-term impact of integrated catchment management practices is beneficial, although costs are higher in the early years. However, poorer farmers, who are more likely to be dependent on agriculture for their livelihood, are likely to prefer less labour intensive approaches. As a result, they are not likely to implement environmental measures unless they can be persuaded of their value or be compensated for the additional cost. Their commitment to effecting long-term returns and environmental benefits in the uplands is also likely to decrease, as alternative off-farm employment becomes more available. However, the impact of erosion neglect would affect a much greater area than Wang Jia Catchment and the local farming community. If widespread adoption of environmentally sustainable agriculture on upland slopes is desired in preference to more environmentally damaging high value crops, then the government may need to provide incentives to farmers to engage in the new practices. Policy recommendations are listed in Section 7.7.

7.5. Specific Conclusions from Work Package 4

The results show that the impacts of different contour cultivation practices on soil properties, soil loss, runoff, stored soil water, crop water use efficiency and yields varied with rainfall characteristics during the three years of experiments. Generally, CRP (contour ridge cultivation with polythene plus straw mulch, **INCOPLAST**) was the best method for maintaining soil fertility, improving soil structure and retaining most stored soil water, thus leading to the highest crop water use efficiency for biomass production, compared to CC (contour cultivation), CR (contour ridge cultivation without mulching) or AL (alley cropping). AL conserved most soil and water by reducing soil loss and runoff, while CRP induced higher runoff during the wet seasons, but effectively conserved soil water by reducing soil water evaporation during the dry period compared to CC or CR. AL was the most conservative method and the best practice for both improving corn yield and reducing runoff and erosion on highland slopes. CRP was the second best for corn yield production and soil conservation, but it was the best method for conserving soil water, giving the highest water use efficiency and lablab bean yield during the dry season.

7.6. Specific Conclusions from Work Package 5

Throughout the duration of the project, the team generated research output in a variety of media, including published papers, research theses, conference papers and posters at both

Chinese and international conferences. In Year 4, emphasis was placed on the preparation of detailed papers, relating to individual work packages, for international refereed journals. WWW pages on the Project are 'on-line' and regularly updated. Project outputs have been disseminated in China via local media and publication in Chinese journals and agricultural magazines. There has been a programme of farmers' workshops held in the catchment, with dissemination material being provided for farmers and extension workers. Outputs are also included in the degree courses of agriculture students at YAU. EU 'Accompanying Measures' funding was used to organise the *'Workshop on Sustainable Highland Agriculture in South-East Asia* (**SASEA**)' in Yunnan. The main aim was to introduce the research findings of the Project to potential users. It targeted and integrated research users, policy-makers, the scientific research community, local farmers and extension workers and had two components: one a post-Congress tour ('*Red Cloud Tour'*) of the 17th World Congress of Soil Science, Bangkok, Thailand (August 14-21, 2002); the other a workshop at Kunming, Yunnan Province. The work of the Project was also represented at the China Hi-Tech Fair (Shenzhen, 2002).

7.7. Limitations of the Study, General Recommendations and Further Work

7.7.1. Limitations of the Study

By their very nature, such projects are limited. The Project was limited in both space and time. To achieve Project aims, relatively small areas were selected for study (total area c. 50 ha). Furthermore, the Project was limited in time to four years duration, hence the maximum number of summer cropping seasons that could be studied was three and the long-term effects of the biological measures could not be evaluated. Other limitations were the inability of the project to monitor the effects of treatments on soil and water conservation at the catchment scale, conduct a complete baseline survey at an earlier stage in the project, or assess systematically the voluntary adoption of the best practices during the funding period. The location of the site on soils overlying limestone prevented the Project from carrying out a full hydrological survey and it became clear that the most serious contributors to erosion in the catchment were not the agricultural practices but the occurrence of gully erosion, slope instability and anthropomorphic damage. However, some of these limitations are generic and others were unavoidable. In the circumstances, the Project team aimed to maximise project outcomes and some of the limitations such as long-term monitoring and assessment of voluntary adoption will be conducted after the end of the Project, under separate funding. Furthermore, the team achieved evaluations of the maximum number of cropping seasons possible, to enable full statistical analyses of data.

7.7.2. Scientific Recommendations

1. Where the priority is to increase corn yields on sloping land under conditions where the risk of soil erosion is low, contour planting with single ridge polythene mulch is recommended. Where the risk of soil erosion is higher, or rainfall is likely to be limiting early in the growing season and irrigation water is available for application <u>prior</u> to the application of polythene mulch, the **INCOPLAST** technique is recommended. Where this technique is used, straw <u>must</u> be readily available to be used as the mulching material.
2. In all cases, the availability of sufficient manure and, in the case of **INCOPLAST**, the availability of sufficient straw, may be major constraints. The availability of sufficient water for early season irrigation will also be a constraint when rainfall in May and June is considerably below average. At a catchment level, the provision of an irrigation system, particularly for early season establishment should be considered a priority for reliable improvements in productivity.
3. The soil and water conservation benefits of polythene mulch/intercropping with soybean have not been evaluated in this study but, if the effects are similar to those of **INCOPLAST**, this practice may be recommended where soybean production is important, without significant reduction in corn yield. However, based on the results from three seasons, soybean yield is less reliable than that of corn.

4. These scientific outcomes should be, and currently are being, incorporated into the further development of a land management plan for the catchment, along with the outcomes from the other work packages.

7.7.3. Policy Recommendations

The following approaches are recommended:

1. Training for on-farm work in order to appreciate the significance of the superior returns to new cultivation practices, which have both short term and long-term positive impacts.
2. Since women are primarily engaged in farm work, while men take on off-farm work, training for on-farm activity should ensure the inclusion of women.
3. Training for off-farm work, since increased income to farm households will come primarily from off-farm employment. This assumes that increased off-farm work does not decrease emphasis on soil conservation practices, which may be a problem.
4. Encouraging the legal market in land use, where households can retain user rights but can rent them out to those farmers who are willing and can get a higher return from this land, particularly through economies of scale.
5. Identifying higher value products for production on the small hill slope plots to give a higher return to labour. This will require an organisation and integration of inputs and outputs (perhaps through cooperative actions) in order to generate the required externalities.
6. Government support and promotion of investment in irrigation and environmental projects, recognising the high time preference of farmers and taking into account not only the private gains to farmers, but also the wider social gains through the prevention of soil erosion and river silting.
7. Creation of off-farm employment through improving the institutional environment and through greater public sector involvement and possibly improving downstream processing and commercialisation of the agricultural products.

7.7.4. Further Work

Project work is continuing. Mrs. Wang Shu Hui and Prof. Liu Hong Mei have nearly completed their Ph.D. theses and both should have finished by April/May 2003. Prof. Li Yong Mei has completed her field and laboratory studies in Wang Jia and is about to start writing her Ph.D. thesis. The thesis title is “Soil Productivity Assessment in a Representative Catchment in the Highlands of Yunnan Province, Southwest China” and is registered at the University of Wolverhampton. Professor Li travelled to the UK in March 2003 to write her thesis and it is anticipated the thesis will be completed by December 2003. This activity is funded by a scholarship from the Chinese Government. Two further M.Sc. projects are in progress, one in Yunnan and one in Thailand, and both are scheduled for completion in July 2003.

A further Ph.D. project is in progress, entitled “Developing Sustainable Agricultural Systems in Upland Areas of South West China and North Vietnam”. This project is fully funded by The University of Wolverhampton and is scheduled for completion in June 2004. The project is asking the fundamental question: what controls whether an agro-environmental development research project is successful or not? The researcher is developing a generic series of protocols to evaluate such projects and is applying these in Wang Jia Catchment. Protocol development and project evaluation are being achieved by using a variety of techniques, such as participatory rural appraisal and diagnostic erosion surveys. In July 2003, the study will be extended to a smaller scale evaluation of the experimental site in Vietnam, currently being studied by Hohenheim University (Germany). The researcher, Mr. Madhu Subedi, is a Nepalese national. It is Mr. Subedi’s intention to return to Nepal on completion of his studies, to assist in agro-environmental development in Nepal.

Currently, Wang Jia Catchment is a functional integrated catchment study, with a management plan, which is evolving as the longer-term outcomes from the project are realised. It is now serving as an observatory and model. Discussions are on-going for the long-term maintenance of the catchment scheme as a research, training, extension and demonstration facility, supported by Yunnan Provincial funding. The research team is actively engaged in preparing proposals for further research projects, using the **SHASEA** Project as a solid foundation. Proposals are in preparation for various sponsoring agencies, including the European Commission's 'Framework 6'.

MANAGEMENT REPORT

1. ORGANISATION OF THE COLLABORATION

Overview of how co-operation between partners was achieved and improved.
Co-operation between partners proceeded very well. The concertation meetings, especially the field visits, offered ideal opportunities for interaction and evaluation of progress, both per task and per partner. Joint discussions resulted in the planning of future developments, the production of outline plans, the identification of milestones and the exchange of information and ideas. A Consortium Agreement was produced, to enhance smooth co-operation between the partners. This outlined a 'Code of Conduct', which all partners agreed to adhere to during the project. Regular contact between the Asian and European partners was established through e-mail, fax and telephone. The Chinese Project Managers acted as the main contact for all activities in Yunnan associated with the EU project. The European Project Managers co-ordinated activities between the European partners. They organised annual concertation meetings in Europe and South-East Asia, in co-operation with the responsible Work Package Co-ordinator. They also acted as the link between European and Asian partners in day-to-day project management, working in close co-operation with the Chinese Project Manager. The European Project and Chinese Managers collaborated on the production of project pamphlets in both Chinese and English. In addition to concertation meetings, there were periodic visits between partners, which were fundamental to ensuring the project moved ahead in an integrated manner.

As the Project progressed, the exchange of results and ideas between partners responsible for different disciplines increased, leading to a further unification of the research strategy. The funding awarded as part of the 'Accompanying Measures' programme enabled further collaboration between scientists and local soil conservation agencies, farmers and government workers. In the final year, this programme was implemented with two linked events: the 'Red Cloud Tour', a Post-Congress Tour of the '17th World Congress of Soil Science' (Bangkok, August 2002) and the Kunming Workshop, a discussion workshop on the applicability of results to sustainable highland development in South-East Asia. These are reported in the separate report 'Workshop on Sustainable Highland Agriculture in South-East Asia' (SASEA; Contract No. ICA4-2001-50022).

Critical review of the level of collaboration achieved, main problems encountered and recommendations on how to improve it in future contracts
The level of collaboration was excellent. Some minor problems occurred and these are specified in the 'problems' section at the end of this 'Management Report'. Collaboration, advice and support from the EU were excellent and we are grateful to the Desk Officer, Mr. Dirk Pottier, for his friendly co-operation. In terms of future contracts, it is advisable to very clearly specify exact rules of financial management. Often the research team were able to produce research results quicker, more efficiently and cheaper than stated in the project proposal. However, we note that in 'Framework 6' more responsibility is devolved to research teams, which we support as a very positive step.

2. MEETINGS

Summary of project meetings: date, place, purpose, participants and results. Minutes and agreements have been submitted separately to the European Union.

Concertation Meeting 1
Date: 31 January - 7 February 1999
Location: Yunnan Agricultural University, Kunming, Yunnan, P.R. China
Purpose: Plan the project; agree implementation strategies; participate in field programmes; review progress.
Participants: Yunnan Agricultural University (YAU), Chiang Mai University, Thailand (CMU), the National University of Ireland, Galway (UoG), Gembloux Agricultural University, Belgium (GAU), Macaulay Land Use Research Institute, Aberdeen, U.K. (MLURI) and The University of Wolverhampton, U.K. (UoW).
Results: An agreement on 23 points was reached.

Concertation Meeting 2
Date: 21-31 July 1999
Location: Chiang Mai University, Thailand & Yunnan Agricultural University, Kunming, P.R. China.
Purpose: Plan the project; agree implementation strategies; participate in field programmes; review progress.
Participants: YAU, CMU, UoG, GAU and UoW.
Results: An agreement on 26 points was reached.

Concertation Meeting 3
Date: 24-28 January 2000
Location: Gembloux Agricultural University, Belgium
Purpose: Plan the project; agree implementation strategies; review progress.
Participants: YAU, CMU, UoG, GAU, MLURI and UoW. There was also a visit by Mr. Dirk Pottier from the EU (DGXII) on 27/1/00.
Results: Seventy-one points of agreement were reached.

Concertation Meeting 4
Date: 24-29 July 2000
Location: Yunnan Agricultural University, Kunming, Yunnan, P.R. China
Purpose: Review progress to date on all work packages; discuss and plan future work; agree implementation strategies; visit Wang Jia Catchment and review progress.
Participants: YAU, CMU, UoG, GAU and UoW. Unfortunately, Dr M.J. Wilson from the Macaulay Land Use Research Institute (MLURI) was unable to attend due to health problems.
Results: Fifteen major agreements were reached.

Concertation Meeting 5
Date: 22-26 January 2001
Location: University of Ireland, Galway.
Purpose: Review progress to date on all work packages; discuss and plan future work; agree implementation strategies.
Participants: CMU, UoG, GAU, UoW and Dr David Hannaway (Oregon State University, USA).
Results: The meeting was successful. Unfortunately no one from YAU was able to attend, but an e-mail link was set up during the meeting. Fourteen major agreements were reached.

Concertation Meeting 6
Date: 23 July - 1 August 2001
Location: Yunnan Agricultural University, Kunming, P.R. China, followed by a trip to Pangmapa, Thailand (28 July - 1 August 2001)
Purpose: Review progress to date. Bring together results to date from each Work Package. Visit Wang Jia Catchment and review progress. Agree plans for the final year of the Project. Visit Pangmapa field site and review progress.
Participants: YAU, CMU, UoG, GAU, MLURI and UoW. Tirza Molegraaf (M.Sc. student from Wageningen University, The Netherlands).
Results: Retrospective and prospective sessions were held for each Work Package.

Concertation Meeting 7
Date: 21-25 January 2002
Location: The University of Wolverhampton, U.K.
Purpose: To review progress to date and plan for the final year of the Project and the SASEA workshop.
Participants: YAU, CMU, UoG, GAU, MLURI and UoW.
Results: Retrospective and prospective sessions were held for each Work Package. Schedules were drawn up for the SASEA Workshop.

Concertation Meeting 8
Date: 2-6 September 2002
Location: Yunnan Agricultural University, Kunming, P.R. China.
Purpose: To review progress to date and plan for the remaining months of the Project.
Participants: YAU, CMU, UoG, GAU, MLURI and UoW.
Results: Retrospective and prospective sessions were held for each Work Package. The latter covered report-writing, future publication of research results, continuing work by Ph.D. and M.Sc. students yet to complete their theses and proposals for future co-operation.

3. EXCHANGES

Professor Huang Bizhi came to the U.K. on 20 January 2000 to write up his Ph.D. thesis. He returned to China in March 2001, after having spent just over one year at The University of Wolverhampton writing up his research work. He was awarded a Ph.D. by The University of Wolverhampton in March 2001.

Ms. Liu Hong Mei spent four months at the National University of Ireland (Galway) in 2000 to learn new research techniques and methods to use in her research work in Wang Jia. She made a second visit to the National University of Ireland (Galway) on 05/11/01 to analyse and write up data collected for the socio-economic component of the Project for her Ph.D. thesis. Her stay lasted nine months.

In May 2001, a link was made between the SHASEA project and Wageningen University in The Netherlands. An M.Sc. student from Wageningen, Mrs. Tirza Molegraaf, stayed at Chiang Mai University for five months, carrying out research work on the water balance of the Pangmapa plots

Mrs. Wang Shu Hui came to UoW for a year in March 2002 to carry out some soil analyses using Inductively-Coupled Plasma (ICP) spectrometry and to complete her Ph.D. thesis. She had completed a complete draft by 28 February 2003 and is expected to submit her thesis in Spring 2003.

A UoW Ph.D. student, Mr. Madhu Subedi arrived at YAU on 5 June 2002 and stayed until 31 Oct 2002. He carried out a detailed investigation using participatory approaches, viz. household survey and participatory rural appraisal (PRA), and held a farmers' workshop at Kelang village to evaluate the project processes and products. He also had discussions with different stakeholders, including the researchers and extension workers of the local township nearby, to find out the successes and failures of the Project. His work was focused on a study of the (a) comparative analyses of the technologies extended by the Project and the farmers' existing technology, (b) contribution of the technologies extended by the Project in changing the household economy of the farmers and (c) role of the technologies extended by the project in improving environmental conditions within Wang Jia Catchment.

Professor Li Yong Mei arrived at UoW on 22 March 2003 to complete her Ph.D. thesis. Unfortunately, her arrival was delayed due to administrative problems associated with visa documentation.

4. PROBLEMS

The Chinese Project Manager post changed twice, during Years 2 and 3. Professor Li Yong Mei started work as a Ph.D. student on the project to replace Mr. Chen Jiding, who had had to return to his job. Therefore Professor Li could no longer act as Chinese Project Manager. Dr Huang Bizhi took over as Chinese Project Manager with assistance from Mrs. Zhao Yan. The European Project Manager post also changed twice. In Year 2, Mrs K. Rothschild-Van Look left the Project and was replaced by Ms. E. Milne, a Ph.D. student at UoW, who had worked with the Project at YAU. In Year 4, she left to take up another post and was replaced by Dr A. McCrea, a crop and soil science researcher at UoW.

The Ph.D. programme of Professor Li Yong Mei started much later than planned, as she had to start much of the work again after the departure of Mr. Chen. Therefore, it was not possible for her to complete her research within the duration of the Project. Fortunately, Professor Li was awarded a research scholarship by the Chinese Government, which will enable her to complete her Ph.D. studies.

There were several changes in the village and township leadership (Partner 6) during the Project, which made the development of consistent management strategies more difficult. Some approaches had to be revised in order to accommodate local policy changes

There were changes in Provincial Government policy in relation to the cultivation of tobacco, the major cash crop in the region, which had implications for the development of cultivation strategies for the food crops under study. These impacts were beyond the control of the Project team and will influence longer-term Project decisions.

Annex 5.1: Summary of the household survey activities and personnel involved in household survey.

Activities	**2002**	**2003**	**Remarks**
Duration (date) of survey preparation	10 days (28 June - 7 July 2002)	5 days (14-18 July 2003)	
Duration (date) of survey	10 days (8-12 July and 15-19 July 2002)	5 days (21-25 July 2003)	
Questionnaire translation	Mr An Tong Xin	Mr An Tong Xin	
Survey team	Ms Dai Ping Ms Zhang Yan Wen Mr Yuan Yi Dong Mr Dai Long Kun	Mr Xu Honglin Ms Liao Senlin Mr Zhang Yutian Ms Zhao Jingzhi Mr Jun Huozhao Ms Shao Hui Mr Li Hang	Undergraduate students of YAU
	Mr An Tong Xin Mr Fan Mao Pan	Mr An Tong Xin Mr Fan Mao Pan	Teachers of YAU
Co-ordination and logistic help in the village	Mr Shang Kaihua Mr Yang Xinghua	Mr Shang Kaihua Mr Yang Xinghua	Village officials
Technical consultation	Ms Li Yongmei Ms Liu Hongmei	Ms Liu Hongmei	Researchers of the Project
No. of households surveyed	63	61	

Annex 5.2

Increasing Sustainability of Agricultural Systems in Upland Areas of South West China.

<u>Household Survey questionnaire 2002</u>

Survey number:	
Name of the Enumerator:	
Date of the interview:	

1. Household Number: ……………

2. Name of the Respondent:
   Age: [ ] **Years.**

   Sex: [ ] **Symbol: 1 = Male; 2 = Female.**

3. Wealth category:
   [ ] From wealth categorisation exercise (PRA).

4. How many months can you survive from the production from your own fields?

Duration of food sufficiency	Please check appropriate box
Less than 6 months	
6-12 months	
More than 12 months	

<u>General</u>

5. What type of land do you have?

Type of land	Area (mu)	Number of parcels
a. Upland		
b. Paddy land		

6. Major crops grown in the catchment? *(Please check the appropriate box)*.

Crops	1999	2000	2001	2002
Summer crops				
1. Maize				
2. Soybean				
3. Buckwheat				
4. Potato				
5. Vegetable				
6. Others				
Winter crops				
1. Wheat				
2. Pea				
3. Broad bean				
4. Others				

7. What is the productivity trend of different crops in different types of land over the past 3 years (1998 or before)?

Response	**Please check appropriate box**			
	Maize	**Soybean**	**Wheat**	**Pea**
a. Increasing				
b. Same				
c. Decreasing				

8. If the productivity trend is decreasing, then why?

Reasons	**Rank**			
	Maize	Wheat	Pea	Soybean
a. Due to the decrease in soil fertility				
b. Due to the decrease in productivity of crops				
c. Less quantity of farmyard manure				
d. Decrease in efforts and labour				
e. Adverse climate				
f. Other (specify)				

9. If the productivity trend is increasing, then why

Reasons	**Rank**			
	Maize	**Wheat**	**Pea**	**Soybean**
a.				
b.				
c.				

Objective 2: Technical accomplishments

2a: Effectiveness of the technologies

i. Contour planting

10. How do you cultivate sloping land?

[ ] Symbol: 1 = Downslope planting; 2 = Contour Planting; 3 = Both; 4 = No definite pattern.

11. If both, what is the area under different planting methods?

[ ] % under Down slope planting.
[ ] % under Contour Planting.
[ ] % under no definite pattern.

Which planting method do you prefer? (*Please check appropriate box*).

Down slope planting	
Contour Planting	
No definite pattern	

12. Why? Give reasons.

Reasons	**Rank**
a.	
b.	
d.	
e.	

13. Which planting method are you thinking of using in the next season? How are you planning to cultivate sloping land in the next season?

Response	Please check appropriate box
Downslope planting	
Contour Planting	
Both	
No definite pattern	

14. If both, what will be the approximate area under different planting method?

	% under Down slope planting.
	% under Contour Planting.
	No definite pattern.

ii. *Mulching*

a. Straw mulch

15. Is straw mulching a traditional practice?

	Symbol: 1 = Yes; 2 = No.

16. If NO, from where did you learn about mulching technology?

Source of information	Rank
a.	
b.	
c.	
d.	
e.	

17. Did you use straw mulch in the past?

Year	Response (YES or NO)	If yes, area mulched (mu)
1999		
2000		
2001		
2002		

18. If NO, what are the reasons for not mulching? What are the problems associated with the adoption of straw mulching technology? ***Enumerator:*** *Try to find out why farmers decided not to adopt the technology? What are the reasons that made farmers think that the technology is unsuitable?*

Reasons	Rank (1=most important)
a. Not available	
b. Not traditionally used	
c. Not available when required	
d. Not economic	
e. Requires more labour to use	
f. Others (specify)	

b. Polythene mulch

19. Did you use polythene mulch in the past?

Year	Response (YES or NO)	If yes, area mulched (mu)
1999		
2000		
2001		
2002		

20. If NO, what are the reasons for not mulching? What are the problems associated with the adoption of polythene mulching technology?

Reasons	Rank (1 = most important)
a. Not available	
b. Not used traditionally	
c. Not available when required	
d. Not economic	
e. Requires more labour to use	
f. Others (specify)	

21. If YES, since when did you start using polythene for mulching?
    Since [ ] years ago.

22. Where did you learn about polythene mulching technology?

Source of information	Rank
a.	
b.	
c.	
d.	
e.	

23. What do you do with the polythene mulch after the crop harvest? *Ask only if the respondent is using the polythene mulch, refer Q No 20*.

Options	Please check appropriate box
a. Leave in the field	
b. Collect and throw away (when)	
c. Collect and bury	
d. Collect and burn	
e. Collect and sell (recycle)	
f. Other (specify)	

iii. Intercropping

24. Are farmers practising inter-cropping/ mixed-cropping?

Response	Please check appropriate box
Yes	
No	

25. If YES, in how much area are you practicing inter-cropping/ mixed-cropping?
    [ ] mu.

26. Is mixed/intercropping a traditional practice in this region?
[ ] Symbol: 1 = Yes; 2 = No.

27. If NO, where did you learn about mixed/intercropping technology?

Source of information	**Rank**
a.	
b.	
c.	

iv. Pine tree, sweet chestnut and prickly ash plantation

28. Has the project planted trees on your land since 1999?
[ ] Symbol: 1 = Yes; 2 = No.

29. If YES, which species have been planted on your land?

Species	**Please check the appropriate box**
Sweet chestnut	
Prickly ash	

30. Have you planted trees on your land by yourself since 1999?
[ ] Symbol: 1 = Yes; 2 = No.

31. If YES, which species have you planted on your land?

Species	**Please check the appropriate box**
Sweet chestnut	
Prickly ash	
Others	

32. If NO (refer Q No 31), What are the reason(s)………

Reasons	**Rank (1 = most important)**
a	
c	
d	

v. Irrigation system

33. Have used the irrigation system of the project on your land?

Year	**Response (YES or NO)**	
	Summer crops	**Winter crops**
1999		
2000		
2001		
2002		

34. If NOT, why? (Please give reasons).

Reasons	**Rank (1 = most important)**
a.	
b.	
c.	

Increasing Sustainability of Agricultural Systems in Upland Areas of South West China.

Household Survey 2003

Household Number:		Name of the Respondent:	
Age (Years):		Sex:	

Use of irrigation system (follow-up of 2002 survey)

1. Have used the irrigation system of the project on your land?

Year	**Response (YES or NO)**
2002/03 Winter (Last wheat season)	
2003 Summer (This maize season)	

If Not, Why? Reason for not using irrigation

Wheat	**Maize**
a.	a.
b.	b.
c.	c.

2c: Socio-economic impact

2. Did you grow tobacco before 1998 and are you growing after 2002? Please provide the information about the area under tobacco before 1998 and after 2002.

	Planted tobacco? (Yes/No)	**If 'Yes', area planted (mu)**
Before 1998		
During 2003 (i.e., After 2002)		

Local perceptions, security of tenure and stewardship.

3. Do you think the government will take back your land?
   [ ] Yes/No.

4. If Yes, When?
   After [ ] Years.

5. How many years do you want to keep this land?
   [ ] Years.

3a: Dissemination processes

6. Have any of your family members participated in any training provided by project?

Area of training	**Response**	
	Yes	**No**
a. Improved cultivation practices of maize		
b. Improved cultivation practices of wheat		
c.		

3b: Perception of the farmers of the project outcomes, their involvement in dissemination and initial adoption.

7. Have you heard about the technology?

Technology/interventions	**Response**	
	Yes	**No**
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

8. From which source(s) you heard about the technology?

Technology/interventions	**Sources**				
	YAU	**Village office**	**Tobacco Dept.**	**Other farmers**	**Other (Specify)**
a. Straw mulch technology					
b. Polythene mulch technology					
c. Inter-cropping technology					
d. Contour cultivation technology					
e. Grass strips technology					
f. Sweet chestnut plantation					
g. Prickly ash plantation					
h. Irrigation scheme					
i. Others (specify)					

9. Did you participate in the cultivation project technology?

[ ] Yes/No

10. Have you tried the technology?

Technology/interventions	**Response**	
	Yes	**No**
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

11. Are you using any of the project technology this year (2003)?

[ ] Yes/No.

12. Did you benefit from the project's research activity?

[ ] Yes/No.

13. If YES, from which of the following technologies did you benefit?

Technology/interventions	**Form of benefit#**	**Rank (1=most important)**
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

(Note: # = economic, labour saved, production increased, soil-water conserved etc).

14. Reasons for trying/not trying the technology?

Technology/ interventions	**Reasons for**	
	Trying	**Not trying**
a. Straw mulch Technology	1.	1.
	2.	2.
b. Polythene mulch Technology	1.	1.
	2.	2.
c. Inter-cropping Technology	1.	1.
	2.	2.
d. Contour cultivation Technology	1.	1.
	2.	2.
e. Grass strips Technology	1.	1.
	2.	2.
f. Sweet chestnut Plantation	1.	1.
	2.	2.
g. Prickly ash plantation	1.	1.
	2.	2.
h. Irrigation scheme	1.	1.
	2.	2.
i. Others (specify)	1. 2.	1. 2.

15. Will you use the technology in future also?

Technology/interventions	**Response**	
	Yes	**No**
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

16. If NO, What could be the possible reasons?

Technology/Reasons	Rank

17. When you need information/suggestion about the agriculture, where do you go for the help?
(This could be individual, organisation, business shops, political leaders, extension agent etc. If they mention about the organisation, try to understand whether they seek advice from any particular person from that organisation or they don't care about the person. If farmers seek advice from any particular person within that organisation, then write the name of the person and the organisation both, however if they often go to the same organisation but do not seek the advice from any particular person then write the name of the organisation only. – **Farmers' Network Analysis***).*

Contact person/organisation	Rank

Name of the Enumerator:	
Date of the interview:	

Increasing Sustainability of Agricultural Systems in Upland Areas of South West China.

Household Survey (for adoption study) 2003

Serial Number:		Name of the Respondent:	
Age (Years):		Sex:	

A. Awareness level:

1. Have you heard about the technology?

Technology/interventions	**Response**	
	Yes	**No**
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

2. From which source(s) you heard about the technology?

Technology/interventions	**Sources**				
	YAU	**Village office**	**Tobacco Dept.**	**Other farmers**	**Other (Specify)**
a. Straw mulch technology					
b. Polythene mulch technology					
c. Inter-cropping technology					
d. Contour cultivation technology					
e. Grass strips technology					
f. Sweet chestnut plantation					
g. Prickly ash plantation					
h. Irrigation scheme					
i. Others (specify)					

B. Testing Level:

3. Have you tried the technology?

Technology/interventions	Response	
	Yes	No
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

4. Reasons for trying/not trying the technology?

Technology/ Interventions	Reasons for	
	Trying	Not trying
a. Straw mulch Technology	1.	1.
	2.	2.
b. Polythene mulch Technology	1.	1.
	2.	2.
c. Inter-cropping Technology	1.	1.
	2.	2.
d. Contour cultivation Technology	1.	1.
	2.	2.
e. Grass strips Technology	1.	1.
	2.	2.
f. Sweet chestnut Plantation	1.	1.
	2.	2.
g. Prickly ash plantation	1.	1.
	2.	2.
h. Irrigation scheme	1.	1.
	2.	2.
i. Others (specify)	1. 2.	1. 2.

C. Adoption level:

5. Will you use the technology in future also?

Technology/interventions	Response	
	Yes	No
a. Straw mulch technology		
b. Polythene mulch technology		
c. Inter-cropping technology		
d. Contour cultivation technology		
e. Grass strips technology		
f. Sweet chestnut plantation		
g. Prickly ash plantation		
h. Irrigation scheme		
i. Others (specify)		

Name of the Enumerator:	
Date of the interview:	

Annex 6.1: Summary of the survey activities and personnel involved in PRA survey.

a. Wealth categorisation exercise conducted during 2002, Kelang village, China.

Activities	**Details**	**Remarks**
Duration (date) of exercise	1 day (4 August 2002)	
Facilitators	Ms Dai Ping Ms Zhang Yan Wen Mr Yuan Yi Dong Mr Dai Long Kun	Undergraduate students of YAU
	Mr An Tong Xin Mr Fan Mao Pan	Teachers of YAU
Co-ordination and logistic help in the village	Mr Shang Kaihua	Village officials
Technical consultation	Ms Liu Hongmei	Teachers of YAU/Researchers of the Project
No. of farmers participated in the exercise	15	
No. of households categorised in the exercise	150	

b. PRA exercises conducted during 2002 and 2003, Kelang village, China.

Activities	**2002**	**2003**	**Remarks**
Duration (Date) of survey preparation	3 days (2-4 August 2002)	4 days (5-8 August 2003)	
Duration (Date) of survey	5 days (5-9 August 2002)	4 days (11-14 August 2003)	
Questionnaire translation	Ms Liu Hongmei	Mr An Tong Xin	
Facilitators	Ms Dai Ping Ms Zhang Yan Wen Mr Yuan Yi Dong Mr Dai Long Kun	Mr Xu Honglin Mr Zhang Yutian Mr Jun Huozhao Mr Li Hang	Undergraduate students of YAU
	Mr An Tong Xin Mr Fan Mao Pan	Mr An Tong Xin	Teachers of YAU
Co-ordination and logistic help in the village	Mr Shang Kaihua	Mr Shang Kaihua	Village official
Technical consultation	Ms Li Yongmei Ms Liu Hongmei	Ms Liu Hongmei	Teachers of YAU/Researchers of the Project
Number of PRA sessions conducted	4	4	

c. Farmers' workshop conducted during 2002 and 2003, Kelang village, China.

Activities	Details	Remarks
Duration (date) of the workshop preparation	1 day (10 August 2002)	
Duration (date) of the workshop	1 day (11 August 2002)	
Facilitators	Mr Dai Long Kun Ms Zhang Yan Wen Mr Yuan Yi Dong	Undergraduate students of YAU
	Mr An Tong Xin Mr Fan Mao Pan	Teachers of YAU
Co-ordination and logistic help in the village	Mr Shang Kaihua	Village official

Annex 8.1: Summary of the survey activities and personnel involved in plot survey activities conducted during 2002-2003 in Wang Jia Catchment, China.

Activities	**2002**	**2003**	**Remarks**
Duration (date) of survey	2 days (9-10 September 2002)	2 days (2-3 August 2003)	
Survey team	Ms Zhang Yan Wen Mr Yuan Yi Dong	Mr Xu Honglin Mr Li Hang	Undergraduate students of YAU
	Ms Li Yongmei Mr Fan Mao Pan	Mr An Tong Xin	Teachers of YAU
Co-ordination and logistic help in the village	Mr Yang Xinghua	Mr Yang Xinghua Mr Shang Kaihua	Village official
No. of plots surveyed	100	100	

Annex 8.2: Summary of the survey activities and personnel involved in tree survey activities conducted during 2002-2003 in Wang Jia Catchment, China.

Activities	**2002**	**2003**	**Remarks**
Duration (date) of survey	2 days (25-26 September 2002)	2 days (30-31 July 2003)	
Survey team	Ms Dai Ping Ms Zhang Yan Wen Mr Yuan Yi Dong Mr Dai Long Kun	Mr Xu Honglin Mr Zhang Yutian Mr Jun Huozhao Mr Li Hang Duan Jing	Undergraduate students of YAU
	Mr An Tong Xin Mr Fan Mao Pan	Mr An Tong Xin	Teachers of YAU
	Mr Yang Xinghua Mr Jiang Xingli	-	Village officials
No. of sample plots surveyed	Sweet chestnut = 5 Prickly ash = 5 Pine = 5	Sweet chestnut = 10 Prickly ash = 10 Pine = 3	

Annex 8.3: DES - Field Measurements

<u>FIELD FORM: Rill</u>

Site: Plot # 1
Date: 1 August 2003.

Measurement	*Width* *Cm*	*Depth* *cm*
1	15	3.9
2	27	3.8
3	26	4.2
4	34	3.5
5	27	5.0
6	29	8.9
7	24	9.3
8	30	13.6
9	43	15.1
10	36	8.2
11	35	6.1
12	30	5.1
13	28	1.6
14	26	3.7
15	39	14.1
16	44	11.6
17	29	8.2
18	30	8.3
19	32	13.8
20	30	8.6
Sum of all measurements	614	156.6
Average*	WIDTH =0.307	DEPTH = 0.0783
Length of rill (m) = 0.75+1.00+2.40+1.80 =5.95		
Contributing (catchment) area to rill (m^2) = 9.4 x 4.8 = 45.12		

Rem.: to get average divide the sum of all the measurements by the number of measurements made.

Calculations:

(1) Convert the average width and depth of the rill to metres (by multiplying by 0.01).

(2) Calculate the average cross-sectional area of the rill, using the formula for the appropriate cross-section: the formula for the area of a triangle (i.e. ½ horizontal width x depth); semi-circle (1.57 x width x depth); and rectangle (width x depth). Thus, assuming a triangular cross-section it is:

| ½ | x Width (m) | 0.307 | x Depth (m) | 0.0783 | = Cross-sec area | 0.012019 m^2 |

(3) Calculate the volume of soil lost from the rill.

| Cross-sec area (m^2) | 0.012019 | x Length (m) | 5.95 | = Volume lost | 0.071513 m^3 |

(4) Convert the total volume lost to a volume per square metre of catchment.

| Volume lost (m^3) | 0.071513 | ÷ Catchment area (m^2) | 45.12 | = Soil loss (m^3/m^2) | 0.001585 |

(5) Convert the volume per square metre to tonnes per hectare.

| Soil loss (m^3/m^2) | 0.001585 | x Bulk density (t/m^3) | 1.563 | x | 10 000 | = Soil loss (t/ha) | **24.8 t/ha** |

<u>**FIELD FORM: Gully**</u>

Site: Plot # 1
Date: 31 July 2003

Measurement	*Width at lip(w_1) M*	*Width at base (w_2) m*	*Depth m*
1	2.2	0.7	1.8
2	4.1	1.3	1.6
3	4.2	1.1	1.5
4	4.1	0.65	1.6
5	3.7	0.8	1.52
6	3.5	1.0	1.5
7	3.9	0.5	1.8
8	1.6	1.0	2.0
9	1.7	2.3	3.1
10	1.8	0.6	3.1
11	2.1	0.7	3.0
Sum of all measurements	32.90	10.65	22.52
Average*	WIDTH w_1 =2.9909	WIDTH w_2 = 0.9682	DEPTH (d)= 2.0472
Length of gully (m)	38.2m.		
Contributing (catchment) area to gully (m^2)	L x W = 40m x 10m = 400m^2		

* Rem.: to get average divide the sum of all the measurements by the number of measurements made.

Calculations:

(1) Calculate the average cross-sectional area of the gully, using the formula (w1 + w2)÷2 x d.

½ (av width w_1 + av width w_2) | ½ (2.9909+0.9682) | x Depth (m) | 2.0472 | = Cross-sec area | 4.0527 m^2

(2) Calculate the volume of soil lost from the gully.

Cross-sec area | 4.0527 | x Length (m) | 38.2 | = Volume lost | 154.812 m^3

(3) Convert the volume lost to a per metre equivalent, assuming a catchment area of 1 km^2, or 1,000,000 m^2.

Volume lost | 154.812 | ÷ Catchment area (m^2) | 400 | = Soil loss (m^3/m^2) | 0.3870

(4) Convert the volume lost to tonnes per hectare over the whole catchment area.

Soil loss (m^3/m^2) | 0.3870 | x Bulk density (t/m^3) | 1.398 | x | 10 000 | = Soil loss | **5410.7 t/ha**

FIELD FORM: Waterfall Effect

Site: Plot # 1
Date: 30 August 2003.

Measurement number	*Scoop diameter m*	*Scoop radius (diameter/2) r m*	*Scoop depth d m*	*Scoop volume ($1/3\pi x\ r^2\ x\ d$) m^3*
1	0.11	0.055	0.64	0.0020
2	0.15	0.075	0.20	0.0012
3	0.20	0.1	0.40	0.0041
4	0.10	0.05	0.30	0.0008
5	0.05	0.025	0.35	0.0002
6	0.11	0.055	0.66	0.0021
7	0.11	0.055	0.65	0.0020
8	0.18	0.09	0.52	0.0044
9	0.07	0.035	0.39	0.0005
10	0.14	0.07	0.42	0.0021
11	0.15	0.075	0.52	0.0030
12	0.12	0.06	0.30	0.0011
13	0.18	0.09	0.35	0.0029
14	0.29	0.145	0.30	0.0065
15	0.12	0.06	0.29	0.0011
16	0.16	0.08	0.31	0.0021
17	0.15	0.075	0.44	0.0026
18	0.16	0.08	0.46	0.0031
19	0.18	0.09	0.36	0.0030
20	0.10	0.05	0.33	0.0009
Total volume of soil lost from these measurements (m^3)				0.0457
Average volume of soil lost from each scoop (m^3)				0.0023
Field area (m^2)				40m x 3.70m = 148 m^2
Number of scoops				46

Calculations:

(1) Calculate the volume of soil loss for the whole field, based on the number of scoops in the field.

Average volume (m3)	0.0023	x	No. of scoops	46	=	Volume of soil lost from field (m3)	0.1051

(2) Calculate the soil loss per square meter, based on the measured field area.

Volume of soil lost from field (m3)	0.1051	÷	Area of field (m2)	148	=	Volume of soil lost per m2 (m3/m2)	0.0007

(3) Calculate the tonnes per hectare equivalent of this volume of soil loss.

Total volume of soil lost (m^3/m^2)	0.0007	x	Conversion to t/ha (bulk density x 10000)	1.563x10000	=	Soil lost (t/ha)	**11.1 t/ha**

FIELD FORM: Build-up against Tree Trunks/Plant Stem

Site: Plot # 1.
Date: 30 August 2003.

Measurement number	*Depth d m*	*Distance from trunk/stem r m*	*Volume of soil saved $1/2(1/3\pi x\ r^2\ x\ d)$ m^3*	*Contributing area m^2*
1	0.07	1.90	*0.1310*	*2.28*
2	0.07	1.47	*0.0784*	*3.04*
3	0.06	1.08	*0.0363*	*1.19*
4	0.04	1.90	*0.0749*	*3.42*
5	0.06	1.55	*0.0748*	*1.09*
6	0.08	1.60	*0.1062*	*1.84*
7	0.10	1.47	*0.1121*	*2.29*
8	0.06	1.40	*0.0610*	*0.98*
9	0.06	1.20	*0.0448*	*1.14*
10	0.10	1.00	*0.0519*	*0.85*
			Total volume saved (m^3)	0.7713
			Total contributing area (m^2)	18.12
			Age of trees	3

Calculations:

(1) Calculate the annual rate of soil accumulation, based on the age of the trees/plants.

Total volume of soil saved (m3)	0.7713	÷	Age of trees (years)	3	=	Annual volume of soil accumulated (m3/yr)	0.2571

(2) Convert the total volume of soil accumulated to a volume per square metre.

Annual volume of soil accumulated (m3/yr)	0.2571	÷	Contributing area (m2)	18.12	=	Total volume of soil accumulated (m3/m2)	0.0142

(3) Calculate the tonnes per hectare equivalent of this volume of soil accumulated (and, thus, the tonnes per hectare equivalent of soil lost between the tree plant barriers).

Total volume of soil accumulated/ lost (m3/m2)	0.0142	x	Conversion to t/ha (bulk density x 10000)	1.563 x 10000	=	Soil lost (t/ha/yr)	**221.8**

FIELD FORM: Sediment in Drain (I. Rill)

Site: Plot # 1.
Date: 30 August 2003.

Measurement	*Depth of Sediment m*	*Width of Drain m*
1	0.10	0.39
2	0.09	0.36
3	0.07	0.24
4	0.05	0.26
5	0.09	0.25
6	0.08	0.60
7	0.07	0.62
8	0.06	0.75
9	0.08	0.89
10	0.07	0.80
Sum of all measurements	**0.76**	**5.16**
Average*	**DEPTH = 0.076**	**WIDTH = 0.516**
Length of drain:	**(m) = 9.7**	
Contributing (catchment) area to drain:	**(m^2) = 189.1**	

Calculations:

(1) Calculate the average cross-sectional area of the sediment in the drain.

Width (m) $\boxed{0.516}$ x Depth (m) $\boxed{0.076}$ = Cross-sec area $\boxed{0.0392\ m^2}$

(2) Calculate the volume of soil deposited in the drain.

Cross-sec area (m^2) $\boxed{0.0392}$ x Length (m) $\boxed{9.7}$ = Volume deposited $\boxed{0.3804\ m^3}$

(3) Convert the total volume to a volume per square metre of catchment.

Volume deposited (m^3) $\boxed{0.3804}$ ÷ Contributing area (m^2) $\boxed{189.1}$ = Soil loss (m^3/m^2) $\boxed{0.0020}$

(4) Convert the volume per square metre to tonnes per hectare.

Soil loss (m^3/m^2) $\boxed{0.0020}$ x Bulk density (t/m3) $\boxed{1.563}$ x $\boxed{10,000}$ = Soil loss (t/ha) $\boxed{\textbf{31.4 t/ha}}$

FIELD FORM: Sediment in Drain (II. Gully)

Site: Plot # 1.
Date: 30 August 2003.

Measurement	*Depth of Sediment M*	*Width of Drain M*
1	0.27	0.63
2	0.20	0.62
3	0.20	1.04
4	0.35	0.78
5	0.21	0.65
6	0.25	0.80
7	0.28	0.90
8	0.25	0.90
9	0.29	1.30
10	0.26	1.20
Sum of all measurements	**2.56**	**8.82**
Average*	**DEPTH = 0.256**	**WIDTH = 0.882**
Length of drain:	**(m) = 38.2**	
Contributing (catchment) area to drain:	**(m^2) = 400**	

Calculations:

(1) Calculate the average cross-sectional area of the sediment in the drain.

Width (m) [0.882] x Depth (m) [0.256] = Cross-sec area [0.2258m^2]

(2) Calculate the volume of soil deposited in the drain.

Cross-sec area (m^2) [0.2258] x Length (m) [38.2] = Volume deposited [8.6253m^3]

(3) Convert the total volume to a volume per square metre of catchment.

Volume deposited (m^3) [8.6253] ÷ Contributing area (m^2) [400] = Soil loss (m^3/m^2) [0.02156]

(4) Convert the volume per square metre to tonnes per hectare.

Soil loss (m^3/m^2) [0.02156] x Bulk density (t/m^3) [1.398] x [10,000] = Soil loss (t/ha) [**301.5 t/ha**]

FIELD FORM: Rill

Site: Plot # 2.
Date: 30 August 2003.

Measurement	*Width* *M*	*Depth* *m*
1	0.32	0.10
2	0.28	0.11
3	0.30	0.11
4	0.29	0.06
5	0.20	0.10
6	0.27	0.11
7	0.34	0.12
8	0.21	0.07
9	0.47	0.09
10	0.26	0.09
Sum of all measurements	**2.94**	**0.96**
Average*	**WIDTH = 0.294**	**DEPTH = 0.096**
Length of rill (m) = 4.7		
Contributing (catchment) area to rill (m^2) = 4.7 x 0.99 = 4.65 m^2.		

Note: the rill was not very clear.

Calculations:

1 Convert the average width and depth of the rill to metres (by multiplying by 0.01).

2 Calculate the average cross-sectional area of the rill, using the formula for the appropriate cross-section: the formula for the area of a triangle (i.e. ½ horizontal width x depth); semi-circle (1.57 x width x depth); and rectangle (width x depth). Thus, assuming a triangular cross-section it is:

$\boxed{½}$ x Width (m) $\boxed{0.294}$ x Depth (m) $\boxed{0.096}$ = Cross-sec area $\boxed{0.0141m^2}$

3 Calculate the volume of soil lost from the rill.

Cross-sec area (m^2) $\boxed{0.0141}$ x Length (m) $\boxed{4.7}$ = Volume lost $\boxed{0.0663m^3}$

4 Convert the total volume lost to a volume per square metre of catchment.

Volume lost (m^3) $\boxed{0.0663}$ ÷ Catchment area (m^2) $\boxed{4.65}$ = Soil loss (m^3/m^2) $\boxed{0.0143}$

5 Convert the volume per square metre to tonnes per hectare.

Soil loss (m^3/m^2) $\boxed{0.0143}$ x Bulk density (t/m^3) $\boxed{1.318}$ x $\boxed{10000}$ = Soil loss (t/ha) $\boxed{\textbf{188.0 t/ha}}$

FIELD FORM: Waterfall Effect

Site: Plot # 2.
Date: 30 August 2003.

Measurement number	*Scoop diameter m*	*Scoop radius (diameter/2) r m*	*Scoop depth d m*	*Scoop volume ($1/3\pi x\ r^2$ x d) m^3*
1	0.21		0.18	
2	0.13		0.12	
3	0.30		0.16	
4	0.18		0.12	
5	0.22		0.14	
6	0.20		0.12	
7	0.17		0.11	
8	0.19		0.11	
9	0.21		0.12	
10	0.19		0.09	
Total volume of soil lost from these measurements (m^3)				0.0144
Average volume of soil lost from each scoop (m^3)				0.0014
Field area (m^2)				5m x 5m = 25 m^2
Number of scoops				48

Note: This is the measurement of scoop made by waterfall just behind the maize plant towards the down slope.

Calculations:

(1) Calculate the volume of soil loss for the whole field, based on the number of scoops in the field.

Average volume (m^3)	0.0014	x	No. of scoops	48	=	Volume of soil lost from field (m^3)	0.0691

(2) Calculate the soil loss per square meter, based on the measured field area.

Volume of soil lost from field (m^3)	0.0691	÷	Area of field (m^2)	25	=	Volume of soil lost per m^2 (m^3/m^2)	0.0028

(3) Calculate the tonnes per hectare equivalent of this volume of soil loss.

Total volume of soil lost (m^3/m^2)	0.0028	x	Conversion to t/ha (bulk density x 10000)	1.318x 10000	=	Soil lost (t/ha)	**36.4 t/ha**

FIELD FORM: Build-up against Barrier

Site: Plot # 2.
Date: 30 August 2003.

Measurement	*Measured Depth* *m*	*Measured Length* *M*
1	0.10	1.65
2	0.10	1.48
3	0.13	1.30
4	0.10	1.45
5	0.12	1.40
6	0.10	1.35
7	0.06	1.10
8	0.11	0.90
9	0.08	1.05
10	0.10	1.00
Total	**1**	**12.68**
Average	**0.1**	**1.268**
Length of barrier (m) = 7.7m.		
Contributing (catchment) area to barrier (m^2) = 9.8 x 6.1 = 59.78m^2.		

Note: This hedge does not belong to the plot, so this soil loss is not from the plot. The observation was taken from the adjoining terrace toward west (very small band (width) of land where the hedge was growing. Small cabbage was being grown in the upper terrace under down slope cultivation practice. The barrier was situated along the major slope

The catchment area was difficult to measure as the whole upslope could serve as the catchment to this barrier. I have measured the area of the upper terrace just for the calculation purpose.

Calculations:

(1) Convert the average depth and length of the accumulation against the barrier to metres (by multiplying by 0.01).

(2) Calculate the average cross-sectional area of the accumulation, using the formula for the area of a triangle.

½ x Depth (m) 0.1 x Length (m) 1.268 = Cross-sec area 0.0634m^2

(3) Calculate the volume of soil accumulated behind the barrier.

Cross-sec area (m^2) 0.0634 x Barrier (m) 7.7 = Volume accumulated 0.4882m^3

(4) Convert the total volume accumulated to a volume per square metre of contributing area.

Volume accumulated (m^3) 0.4882 ÷ Contributing area (m^2) 59.78 = Soil loss (m^3/m^2) 0.0082

(5) Convert the volume per square metre to tonnes per hectare.

Soil loss (m^3/m^2) 0.0082 x Bulk density (t/m^3) 1.318 x 10,000 = Soil loss (t/ha) **107.6 t/ha**

(6) Convert the total soil loss as represented by the soil accumulated behind the barrier into an annual equivalent.

Soil loss (t/ha) ______ ÷ Time (yr) ______ = Annual soil loss ______ t/ha/yr

FIELD FORM: Rill

Site: Plot # 5.
Date: 30 August 2003.

Measurement	*Width* *cm*	*Depth* *Cm*
1	10	5
2	11	4
3	20	7
4	15	5
5	10	4
6	16	5
7	17	6
8	16	4
9	18	3
10	14	8
11	26	7
12	23	4
13	25	7
14	20	3
15	10	4
16	12	4
17	34	6
18	10	5
19	20	7
20	12	4
Sum of all measurements (cm)	339 cm	102 cm
Average (m)	WIDTH = 0.1695m	DEPTH = 0.051m
Length of rill (m) = 3.30 + 3.30 + 0.90 = 7.50m.		
Contributing (catchment) area to rill (m^2) = 8.9m x 1.87m = 16.643m^2.		

Note: The catchment area was difficult to measure as the whole upslope could serve as the catchment to these rills. I have measured the area using my judgement.

Calculations:

1 Convert the average width and depth of the rill to metres (by multiplying by 0.01).

2 Calculate the average cross-sectional area of the rill, using the formula for the appropriate cross-section: the formula for the area of a triangle (i.e. ½ horizontal width x depth); semi-circle (1.57 x width x depth); and rectangle (width x depth). Thus, assuming a triangular cross-section it is:

½ x Width (m) [0.1695] x Depth (m) [0.051] = Cross-sec area [0.0043 m^2]

3 Calculate the volume of soil lost from the rill.

Cross-sec area (m^2) [0.0043] x Length (m) [7.5] = Volume lost [0.0324 m^3]

4 Convert the total volume lost to a volume per square metre of catchment.

Volume lost (m^3) [0.0324] ÷ Catchment area (m^2) [16.643] = Soil loss (m^3/m^2) [0.0019]

5 Convert the volume per square metre to tonnes per hectare.

Soil loss (m^3/m^2) [0.0019] x Bulk density (t/m^3) [1.1414] x [10000] = Soil loss (t/ha) [**22.2 t/ha**]

Annex 8.4: Summary of the survey activities and personnel involved in economic analysis PRA survey.

Activities	**2002**	**2003**	**Remarks**
Duration (date) of survey	7 days (5-10 and 22 October 2002)	2 days (26 August and 26 September 2003)	
Survey team	Mr An Tong Xin	Mr An Tong Xin	Teachers of YAU
Co-ordination and logistic help in the village	Mr Shang Kaihua Mr Yang Xinghua	Mr Shang Kaihua Mr Yang Xinghua	Village official
No. of interviews	20	3	23 in total
	8	3	Tree planting
	4		Irrigation
	4		Mulching
	1		Intercropping
	3		Maize Vs tobacco